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INTERNATIONAL EXHIBITION OF 1876.

CONNERY'S CONCAVE CALKING.

No. 23.

IMMEDIATELY adjoining the exhibit of the Hartford Steam Boiler Inspection and Insurance Co.—and most appropriately—is that of Mr. James W. Connery, the patentee of the new system of calking boilers, illustrated by Figures 1 and 2 on this page. The novelty in this method of making the seams and joints in steam boilers and other plate-iron vessels designed to hold liquid or gaseous matters, is of that degree of simplicity as to be almost insignificant; but it is so far-reaching, and of such deep importance in its results, as to merit a foremost place among the multitude of novelties in machine construction on exhibition here.

Among the specimens in the exhibit of the Hartford Steam Boiler Inspection and Insurance Co. are several of fractured plates resulting from defective calking, and Mr. Connery himself exhibits a number of pieces of boiler seams which have been taken apart to show the scoring upon the lower sheet by the careless use of the ordinary flat-ended calking tool.

Figure 1 illustrates very well the difference between the old and the new systems, and Fig. 2 shows the method called "split calking." The old and most commonly used plan is to chip or plane the edge of the overlapping sheet, leaving a solid angle to it of about 80°, and then to drive up by means of a hammer upon the tool shown at the left, the metal at the angle, with the under face of the tool resting upon the under sheet, until the angle of the metal of the upper sheet has assumed something near the form there shown. Any one who has used this kind of calking tool knows that the part made to impinge upon the edge of the sheet can not make equal angles with the sides; for when such is its form it is impossible to keep it in contact with the under sheet under the blow, the tool violently slipping upward upon the inclined surface chipped or planed on the edge of the overlap. It must therefore be made, as shown in the figure, with one of its angles something more acute than the other, in order that the compressed portion, as shown in darker shade in the figure, shall be given about a right angle, and to do this without the slipping away of the tool. With a tool of this form it is impossible to thoroughly upset or calk the metal of the upper plate without more or less injury or scoring of the under plate, as will very readily be seen when it is remembered that the general direction in which the blow from the hammer is transmitted to the iron is through the axis of the calking tool, and this line would, if produced, pass through the under plate a little beyond the further side of the rivet, while the acute angle of the tool lies next the plate.

For the above reasons, the use of this tool, even in the most skilful hands, will result in some degree in a depression in form of a slight groove in the under plate immediately adjoining the edge of the overlap.

And this will not be the only injury done the under sheet. It is well known that in all processes of hammering, rolling, and otherwise compressing iron it becomes harder and more dense; and in the operation of riveting, with which calking is almost identical, as with all compression by impact, the density and hardness of the metal are increased to a greater degree than in any other way. As there is nothing in the process of calking with this tool which makes any change in the material of the under plate, it follows that the extreme edge of the upper plate while being hardened and compressed will move away from the tool in the direction of the least resistance, and become imbedded, like a reversed copy of the calking tool, in the softer metal beneath it, and thus aggravate the injury done with the tool. These effects are plainly shown on plates which are cut apart after the most careful calking.

But this is not the only serious defect in this method of calking. The tendency in the operation is to compress but a small depth of the chamfered edge, and by its severe pressure upon the lower plate on so small a part of its surface to raise the remainder of the surface of the overlap off the under plate, as indicated by the dotted curve above the proper junction of the two surfaces. Of course, with so small a bearing surface, the joint cannot be so tight or reliable as if it bore upon the whole surface from the rivet out to the edge of the lap. Now this latter effect is, I think, productive of more serious results than even the scoring and injury to the under plate, and in a way that seems to have been almost entirely lost sight of.

The operation of riveting, "pening," and all kindred methods of disturbing the texture of and compressing malleable metals, is a most powerful one. The strains which may be brought upon the contiguous, and in some cases remote, parts of a piece of iron by the operation known as "pening," is something enormous; as witness the breaking through by this process of a hexagon nut of about 6 inches across the faces, to remove it from a large piston rod, where it had become so securely fastened by oxidation as to defy removal by any other means, as the writer has seen it done. The operation of calking with this tool is a similar process, and without doubt tends to raise the undisturbed part of the material of the overlap from off the under plate with immense force, and leaves the metal of the lap on a line through the centres of the rivets, or thereabout, under an exceedingly great strain. Now, as the surface of the under side of the rivet heads is small compared with the continuous line of calking; and, moreover, the form of the outer or conical head of the rivets is such as to leave a comparatively thin and yielding edge to prevent the rising of the lap—it is next to certain that in many boiler seams calked in this manner, the metal of the lap is lifted off the under plate with sufficient force to weaken the whole joint to a point much below the theoretical strength of the iron through the line of rivet holes by the strains thus caused; and where a boiler is calked inside and out, these strains must be exaggerated. I believe that the rupture of so many boiler plates through the line of rivets is largely due to these strains, brought about by calking.

But aside from this, the indentation and channelling of the under plate by the calking tool, and by the driving of the compressed and hardened metal of the overlap into it, is a fruitful source of disaster; and the effect is well illustrated in the figure, as giving to the plate that starting point of fracture with which all mechanics in metal are familiar. Every such mechanic is acquainted with the method of drilling a hole through a piece of metal at the termination of a crack to prevent its further advance, the nicking of a bar of iron when desiring to break it easily, or the placing of a fillet where there would otherwise be an angle. These are familiar instances of the fact that fracture will begin by preference wherever a re-entering angle occurs; and this scoring of the under plate provides just such a re-entering angle as invites fracture whenever sufficient strain is brought upon it. Thus a plate of the same metal or the same plate, as shown in the figure, may with the channelling of the calking tool break without sustaining the slightest permanent set, while the unscored part might be bent through an angle of 90° without breaking. That there is not the least exaggeration in this supposition is established by the fact that this exhibitor has several specimens in his inclosure in which these exact conditions obtain, and of which the figure is a very good illustration.

Of course the injury to the plates is increased many fold when—as is too often the case in boiler shops—this part of the work is intrusted to unskilled or careless hands.

Another of the old forms of calking, and one quite as objectionable so far as the danger from scoring the under plate is concerned, is that of "split calking," shown in Figure 2.

In this method a somewhat thinner tool of about the same form is used; first driving it into the lower part of the square edge of the lap (the latter not requiring to be bevelled in this case), with the acute angle of the tool upward in order to impart to the partially compressed metal the wedge-like form given in the other method by chipping or planing the edge, and as shown on the left in the figure. This is the preliminary operation, and where and when the greatest injury is done or commenced, as the direction in which the tool must be driven is considerably toward the surface of the under sheet. In the second or finishing process the tool has a more nearly square edge for the purpose of riveting up the thin wedge of metal left by the first tool, and in the process of course enters the groove or depression in the lower plate made by the first tool, following it up and increasing its depth as the metal of the lap is further compressed. This plan is adopted solely on account of its superior cheapness, but is regarded by most good boiler-makers as a thoroughly barbarous process, and is by them never resorted to. It is cheaper, by saving the labor of bevelling or chamfering the edge of the lap.

In times now happily well nigh gone, the lap edges were all chipped to the required bevel for the ordinary method by hand, hammer, and chisel, after the plates were riveted up; and in performing this operation a much greater injury was often done to the lower plate by the corner of the chisel, in the hands of careless men or unskilled boys, who were largely set at such work, than is possible with any calking tool. Now, however, all shops of note plane the edges of the sheets to the required angle before riveting them together; and the barbarous operation of chipping is scarcely ever resorted to, except in the case of repairs, where the planer can not be used. And indeed small hand planing-machines are in use for bevelling plates *in situ;* otherwise the improvement of Mr. Connery might in some cases be nullified in its advantages, by a careless or ignorant performance of the preparation of the sheet for the application of his tool.

As shown in Figure 1, the improvement of Mr. Connery consists in using a tool with a semi-cylindrical end, producing a concave depression in the bevelled edge of the lap. As the crown of the curve of the tool is entered in the edge of the plate at such a distance from the under plate as will leave, when finished, a considerable thickness of metal between the concave groove and the lower plate, the surface of the compressed and hardened metal driven down upon the lower plate will be too large to cause any appreciable disturbance of the surface of the under plate, while the tool can under no circumstances injure or mar the lower plate in any way.

It will be readily seen, too, that this form of tool, commencing as it does on a small surface for indentation of the edge, must result in carrying the compression or condensation of the iron of the lap to a much greater depth than is possible with the old method, thus bringing the lifting strain suggested above as resulting from the calking, more nearly under the thick part of the head of the rivet, and therefore tending to bring about a permanent strain upon the iron through the line of rivets in a much less degree. This is indicated on the left of Figure 1 by the deep wedge of dark shading, running nearly into the rivet.

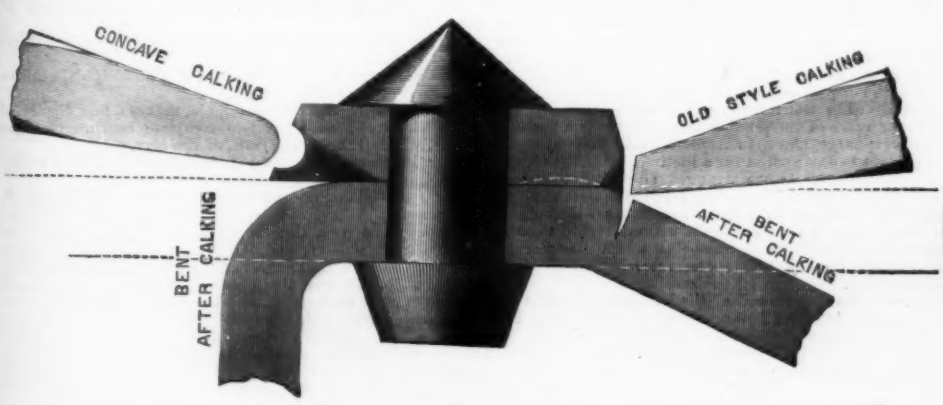


FIG. 1.

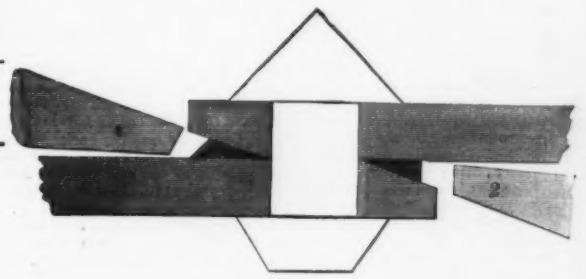


FIG. 2.

The advantages of this kind of calking over either of the old methods is fully borne out by the test of actual trial and practice; and besides a number of specimens of work, in which it has been subjected to comparative test with the old method, and which are very interesting, the inventor exhibits a cylindrical riveted shell, with hemispherical ends, calked on his system, which has been subjected to a pressure of 415 lbs. to the square inch, without leaking.

Among the many new and good things at the Centennial, this invention is entitled to much consideration at the hands of the engineering community. J. T. H.

THE INTERNATIONAL EXHIBITION OF 1876.

THE RUSSIAN ARTILLERY EXHIBIT—NEW FIELD-GUN CARRIAGE.

No. 24.

IN the Russian artillery section, Machinery Hall, there is on exhibition a new iron gun-carriage for field artillery, which possesses several quite novel features, and which will be of no little interest to war-making people. The amount of ingenuity exercised and the labor and pains taken in the invention and manufacture of implements designed to destroy human life, is no better exemplified at the Exhibition than in that of the Russian War Department. And among the recent effective and ingenious improvements in this branch of human industry the carriage above mentioned is no insignificant item.

One of the principal difficulties to be contended with in the use of field artillery as heretofore constructed is in the recoil of the weapon, causing a very considerable displacement of the gun's position when fired, and necessitating the loss of a good deal of valuable time in replacing and retraining, and labor in bringing the piece again into position; or else sub-

jecting it to destructive wear and tear, with risk of disability from fracture or displacement of some of its parts if means are taken to prevent change of position, such as must subject the carriage to injurious strain.

In the discharge of any gun whatever, the momentum of the projectile at the instant of leaving the muzzle of the gun is exactly equal to that resident in the gun and carriage, and if both are equally free to move, the velocities of the projectile on the one hand, and the gun and carriage on the other, will be in the inverse ratio of their weights. As it is of the highest importance in a field gun to reduce the total weight of gun and carriage to a minimum, for facility of transportation and rapidity of handling while in action, the question of recoil becomes a more serious one than in any other form of gun; and artillerists have heretofore been obliged to sacrifice availability and rapidity of accurate fire while in action quite largely to the inexorable demand for lightness, made imperative by the fact that field artillery must be capable of transport over various and difficult kinds of surface. With the carriage under consideration—the invention of Col. Englehardt, of the Russian Artillery,—the design has been to bring every thing down to the least weight, provide an elastic recoil within the mechanism of the carriage itself, and to anchor or chock the gun and carriage, so as to prevent any considerable movement at the time of discharge. For small guns, such as are used in some of the more mountainous countries of Europe, this question is a serious one, as with a sufficiently heavy carriage proportioned to the calibre of the gun or weight of projectile is necessitated a weight which will not permit of their easy transportation in such places. But this improvement is of equal, if not greater, importance where field guns may be and are used, from 4 up to 9 pounders, as in the comparatively level parts of Russia and its possessions.

Like several of the recent improvements instituted and adopted in the Russian War Department, this carriage is the result of a fixed purpose on the part of that Government to overcome the difficulties encountered in practice, as indicated above, by delegating one of its ablest officers to carefully examine every thing in the way of field-artillery carriages on exhibition at the International Exhibition at Vienna, and elsewhere; make minute examination of them in every part, and then apply himself to the improvement of the design and construction to the best of his ability; and the result as embodied in this gun carriage—just as with the "Fortress Gun" described in a former letter—shows that Government funds are judiciously expended in that way, and that it receives more than a *quid pro quo*. Independently of the elastic recoil buffer, this carriage may be said to embody the best ideas developed in all the gun carriages at the Vienna Exhibition.

Previous to the production of this carriage, those made of iron were built up of plate and angle iron, riveted together for the sides or "cheeks," with the single exception of those made by Krupp in Germany; and the first improvement instituted by Col. Englehardt was to make the "cheeks" of one plate of metal, pressed into form where flanged at the edges. In this way superior strength was obtained, with a saving of weight equal to all rivet heads, and one half the total thickness of iron, where angle iron and plate were in contact in the old style; to say nothing of the very much finer finish and general contour given to the structure. The "cheeks" are now very successfully and much more cheaply made in that way, as shown in the figures.

The next improvement made was that of the elastic recoil which, after extended trials with various substances and devices for their application, was decided upon as shown. At the front end of the carriage, bolted to the under side of the "cheeks," are two yokes, forming slots, in which the axle has a short sliding motion in the direction of the length of the carriage. To the axle are connected two diagonal side rods leading back to a strong bolt, which passes through crosswise at about the middle of the length and height of the "cheeks," and which also has a sliding motion in suitable slots formed in the "cheeks," equal in extent to that of the axle. This cross bolt is encompassed by the square eyes of two bolts leading back through seven slabs or layers of cork—which substance was found to more nearly meet the requirements of the case than any other tried—incased in a light iron covering at its sides, and ending in a strong plate of iron through which the eye-bolts pass, and are made to draw upon by means of nuts upon the outside. These nuts serve to adjust the compression given to the cork. A slab of wood forms the bottom layer of the buffer, and this is supported against an iron cross plate riveted to the "cheeks." In this way the recoil of the gun first transmitted to the body of the carriage is conveyed to the axle through the elastic cork buffer, when with the wheels chocked sufficient elasticity is found in the buffer to distribute the force of recoil through a sufficient distance in the sliding of the axle in the slot, to render the backward motion of the whole comparatively small. In extended experiments with a 9-pounder gun, with and without the buffer, the average retrogression of the carriage was with buffer 9 inches, and without about 7 feet, every thing else being equal.

An improved form of "anchor" or "spike" is shown on the rear end of the carriage, which extends across its entire width at that point, and is of such form as to take a large and very firm hold of the earth, which would not be admissible on a carriage without the buffer, as then the major part of the recoil would be transmitted to that point, and soon result in the destruction of the carriage; for this reason the usual "spike" is made of such form as to penetrate or plough up the ground with comparative ease.

The trunnions of the gun are placed further forward than is generally done, with the view of making the load less upon the men when "limbering," and to more nearly counterbalance the weight of the gun when on the march, or attached to the caisson.

The elevating apparatus consists of a differential screw, which is operated by an exceedingly handy contrivance. Attached to the screw head is a kind of thin spur wheel, between the teeth of which a pin on the lower side of the lever fits. The lever has a motion around the axis of the screw, as well as a vertical one on a horizontal joint, as shown. The vertical motion of the lever engages or disengages the pin and the cogs of the wheel, while its horizontal movement serves to give motion to the wheel while the pin is inserted or passed from one space to another when lifted out. One man can with the greatest facility sight and adjust the elevation of the 9-pounder gun, where it has always required two with the old method.

The wheels not shown in the drawings have metal hubs—the first of this kind ever used on field-gun carriages. The body of the carriage is parallel in the old styles of iron, while with the new the taper form of the wooden beam carriage is given to it, which gives to it a better proportioned and lighter appearance. Since the above drawings were made there have been sundry minor improvements made in it, particularly in the training lever, and as yet it is not decided by the Russian Government to adopt it as a completed war instrument, although it is expected that such adoption will be made, as soon as these minor improvements are perfected; the Government has, however, already adopted the general design of the carriage as a system. One of the iron carriages of the old system is on exhibition by its side, which enables one to understand the value of the improvements made very clearly.

When Col. Englehardt first submitted this carriage to the Government for trial, the older officers were quite sceptical as to the merit of the supposed improvements; but at the solicitation of the inventor it was subjected to the severest tests, and it came out of the ordeal triumphantly. The inventor's experiments were conducted from July, 1874, to April 2d, 1875, when it was submitted to the first official trials.

It was tested first officially under a 9-pounder brass gun with charges of 3, 5, and 6 lbs. (Russian) powder of large grain—grains about ¼ inch diameter—without the cork buffer. These experiments were made to test the strength of the carriage and its ability to withstand the heaviest shocks which could in practice be brought upon it. To effect this a depression was made in the hard frozen ground, practically unyielding, into which the rear end of the carriage was placed. With some of the larger charges the gun and carriage were turned completely over backward, and in others it was thrown over on its side and displaced from its position when fired, in various ways, without any injury to the carriage. These experiments were made more particularly to test the strength of the pressed "cheeks."

From April 2d to August 12th, 603 experimental shots were fired—on the latter day 100; and on the 26th of August 130 shots, varying on the several days from 10 to 130 per day; 100 of these were made without the cork buffer, with the rear end against a permanent abutment, and the remainder as arranged and used for practice with the buffer and all complete. After the official trials, 93 more shots were made with it, all without the least injury whatever to either gun or carriage. The identical carriage which underwent this ordeal is on exhibition, and seems to be as perfect in all its parts as when newly brought from the factory.

Since the opening of the Russian exhibit here, Captain Von der Horven, the officer in charge of the artillery section, has received a letter from Colonel Englehardt, stating that 1120 shots have been fired from a 4-pounder of the same system, with the heavy charge of 5½ lbs. (Russian) of large grain powder, giving an initial velocity of 1530 ft. per second, and that the carriage is practically as good as before trial.

This carriage is manufactured at the Samson Engineering Foundry and Wagon-Building Works Company, St. Petersburg. J. T. H.

EXHIBITION NOTES.

INTERESTING MINERALOGICAL AND ARCHÆOLOGICAL DISPLAYS.

On the south side of the Main Exhibition Building, extending from the central entrance to the eastern end, and between the Main Building and the fence along Elm avenue, are two long, narrow wooden buildings, standing parallel with each other and with the Main Building; these constitute the mineral annex, and are devoted to the display of mineralogical, archæological and geological collections from the various States of the Union. To the scientific visitor this is one of the most interesting departments of the Exhibition, and even to those who are not experts in the branches of science there illustrated, the display can not fail to be interesting and gratifying, as showing the mineral wealth of the nation. The collections of relics of the pre-historic dwellers upon the continent are very large, and the antiquarian may find objects of study sufficient to occupy him for a lifetime.

As a rule the exhibits are arranged according to States, some of the Commonwealths having large and well assorted collections in charge of intelligent attendants, while others seem to have deposited their exhibits without regard to order or classification, and left them unlabelled and in disorder for visitors to select the objects of special interest from the mass as best they may.

Illinois.—In the eastern end of the building adjoining the Main Exhibition building is the exhibit of the State of Illinois. The specimens exhibited are principally from the collection of the Illinois Industrial University. Under the head of building stones are exhibited blocks of brown and white sandstone, of close grain and good color, from the subcarboniferous formations near Carbondale; a very light gray sandstone from Alton; a hard, close-grained limestone from the Niagara formation at Kankakee; and the "Athens marble," a gray limestone, from the Niagara formation at Lemont. A fine specimen of plastic fire clay from quarries at Anna is also shown; it is very dense and tough.

There are also some large crystals of lead from mines on the Mississippi River, seven miles south of Galena, and some fine crystals of carbonate of lime from the Vinegar Hill diggings. A full collection of the shells of Illinois is also shown, and also a collection of samples of grain in glass vessels. These objects are all conveniently arranged in a glass case, and are labelled with the scientific names of the objects. There is a small but interesting and well-arranged archæological collection, consisting of stone axes, flint arrow-heads, tomahawks of stone and iron, etc. On a large screen which stands back of the glass case mentioned are displayed the woods of Illinois. There are about 175 specimens, including 12 species of oaks, arranged in sections about a foot long, showing the bark, a polished and a rough surface, and a portion of the transverse section. A portion of the screen consists of planks of native lumber planed and oiled. There are 22 kinds of wood thus shown, among the ornamental woods being maple, ash, oak, cherry, chestnut and walnut.

Pennsylvania.—There is no mineral display made under the auspices of the State of Pennsylvania, although there are several very fine displays of coal and iron made by individual exhibitors. The State authorities exhibit a number of maps, models, and specimens connected with the second geological survey now in progress under the direction of Prof. J. P. Lesley. Among them are topographical and geological models of the Lehigh Gap in the Blue Mountains, of Logan Gap in Jack's Mountain, at Yeagerville; of the Delaware Water Gap; of Blacklog Gap, at Orbisonia, Huntingdon County; and of the Schuylkill Gap in the Blue Mountains, at Port Clinton. These models are made upon a scale of 1-9600 of nature. The topographical models show all the surface features of the country represented, with the hills, mountains, valleys and rivers in miniature.

The geological models show the formations and stratifications of the rock and soil, and are divided in the centre, showing the dip of the various strata. There is also a large topographical model, 12 feet in length, of the Wyoming and Lackawanna coal fields, prepared at the Towne Scientific School of the University of Pennsylvania, and a beautiful small model of the Oak Hill Colliery, near Scranton, showing the manner of driving the breasts and gangways in the coal veins. This model is on a scale of one inch to a hundred feet and is in a frame about a foot square. There is a model of the Ironton Railroad Company's brown hematite iron ore mines in Lehigh County, colored to show the geological formations, and also a large number of maps showing the topography and geology of those portions of the State which have thus far been surveyed, including a very large map of the central belt of the brown hematite ore mines of York and Adams counties.

A full cabinet of lithological specimens is shown, to illustrate the model of the Blacklog Gap, showing the various shales, limestone, fossil iron ore, Medina red sandstone, etc., and a number of mineralogical specimens from other portions of the State, including corundum, from Chester and Delaware counties, and soapstone from Philadelphia and Delaware counties.

The Cambria Iron and Steel Company, of Johnstown, have a fine exhibit of the minerals used in their business and mined upon their premises, together with some of the manufactured products. An arch is erected, at the top of which are steel and iron rails, and down the sides are rail piles, ingots, blooms, spiegeleisen, "muck ball," mill pigs, Bessemer pigs and coke. Around the base of the arch are arranged coking coal, rolling-mill coal, a large block of coal from the Miller seam at Johnstown, Belgian oven coke, fire clay, etc.

From the Broad Top coal and iron region of Pennsylvania, are exhibited fossiliferous, carbonate and hematite ores, coke, fire clay and pig iron. There are also large blocks of Broad Top coal and very fine specimens of coke made from it.

From the Girard Colliery, at Girardville, Schuylkill County, there is a large lump of anthracite coal, weighing 3 tons 2 cwt.

From the Harleigh Colliery, near Hazelton, there is a lump of anthracite, ten feet long, and weighing 11 tons, 19 cwt.

From the Draper Colliery, at Gilberton, Schuylkill County, there is a lump ten feet long by about five feet square, weighing 14 tons 13 cwt.

From the Hickory Colliery, at St. Clair, Schuylkill County, there is a lump weighing 9 tons, 6 cwt.

The Westmoreland Coal Company exhibit several very large blocks of bituminous coal from their mines in Westmoreland County.

The Souman Collieries, Cambria County, exhibit specimens of "Souman" bituminous coal.

The Kittanning Coal Company exhibit specimens of bituminous coal from their mines in Clearfield and Centre Counties.

The Philadelphia and Reading Coal and Iron Company exhibit a very large block of anthracite coal from Schuylkill County.

A large block of bituminous coal is exhibited from Brockwayville, Jefferson County, Pa.

Robert Hare Powel & Co. exhibit specimens of coals, coke, iron ores and limestone from the Powelton estates.

The Ebervale Coal Company of Pennsylvania exhibit, on the platform outside the buildings, a large lump of anthracite coal.

A. J. Haws, of Johnstown, Pa., exhibits fire brick and fire clay work, tuyeres and other work for iron furnaces.

Charles M. Howells, of Lancaster, exhibits specimens of marble work.

George Danby & Co. exhibit specimens of galvanized sheet-iron ornamental work.

The American Kaolin Company, of Philadelphia, exhibits specimens of fire brick, tile, etc.

Philip Neukumet, of Philadelphia, makes a fine display of fire-brick work, including two complete benches of a gas works, with all the retorts, etc., of fire clay.

Kier Brothers, of Salma, Pa., exhibit fire brick for rolling mills, linings, boshes, hearths, etc.

Michigan.—The State of Michigan has one of the largest, best arranged, and most interesting collections on exhibition. The specimens from the copper region of Lake Superior are particularly numerous and interesting. There is a series of maps of the geological survey of the iron district of the State, made in 1869–'73, and also a cabinet showing the geological section of the iron district, with the various ores and rocks arranged according to their natural position. There are a large number of specimens of the different kinds of iron ore produced, with the analysis by the State chemist attached to each specimen. There is a large mass, ten feet long and weighing 15 tons, of specular slate iron ore, from the Cleveland Iron Co.'s mines in Marquette County. This mass is of the remarkable richness of 66.6 per cent metallic iron. Specimens of "Republic" ores, 66 and 68 per cent fine, are also shown; they are of the micaceous, specular slate and granular magnetic orders. There are also specimens of steely magnetic, brown grape, manganiferous and manganiferous brown, granular magnetic, velvety brown, and hard and soft hematite ores.

In the exhibit of native copper and associate minerals is exhibited a mass of native copper weighing 5720 pounds, found in 1875 in the Minong Mines, on Isle Royale, Lake Superior. It was taken from an ancient mine at a depth of about 16½ feet, and it shows on its surface the stone hammer marks of a pre-historic race of miners. When found, it was resting upon a wooden handspike which lay under it. The ground around was full of charcoal. At the point where it was found, the ancient excavations extend in almost a continuous line for more than two miles, in most instances the pits being so close together as barely to permit their convenient working. The stone hammers, weighing from ten to even thirty pounds, the chief tool with which the labor was performed, have been found in cart-loads. They are either perfect, or are broken from use, and the fragments of large numbers of them are found mingled with the débris on the edge of the pits or at their bottom. It is estimated that at one point alone toward the north side of Isle Royale the amount of labor performed by those ancient and unknown men far exceeds that of one of the oldest copper mines on the south shore of Lake Superior, which has now been constantly worked with a large force for over twenty years.

From the Calumet and Hecla Mine there are large specimens of copper bearing conglomerate, yielding five per cent of pure metallic copper. Also fine specimens of ripple marked sandstone, a handsome specimen of native metallic sheet copper, in a large natural sheet. Also cake, bolt, bar and ingot copper.

Four large blocks of native copper are exhibited, cut from a 76 ton mass at the Central Mines, Keweenau County. This is about 85 per cent pure metallic copper.

There are also some exquisite specimens of native silver, perfectly pure and in the most fantastic and beautiful shapes. Also specimens of native moss copper, where the pure metal is mixed with quartz, and looks like moss; fern copper, where the metal resembles in shape the leaves of fern. There are also several specimens of silver and copper mechanically combined, the two metals being distinctly and clearly marked. There are several beautiful crystals of calcite with copper mingled, also a very interesting collection of ancient copper

tools, knives, chisels, spears, etc. There is a fine specimen of phrenite, with quartz and copper crystals attached. Also a number of jars, with grains of silver and copper mechanically combined, from under the stamp heads of a quartz mill. There are beautiful specimens of agates from Lake Superior.

From Isle Royale are sent specimens of brown sandstone for building purposes. A certificate from General Q. A. Gilmore is attached, setting forth that this stone has stood a crushing test of 44,000 pounds to the square inch.

From Grand Rapids are shown specimens of gypsum rock and manufactured plaster.

From Huron Bay are shown very fine specimens of roofing slate. This is a new industry just developing in Michigan, and the slate is said to be equal in quality to that found in any other portion of the country.

From East Saginaw, Saginaw City, Carrollton, Zilwaukee, Portsmouth, Bay City, Wenona, White Rock and East Tawas, are shown specimens of salt and brine from Artesian wells.

From the Lake Huron Stone Co. are shown specimens of fine grindstones.

From Monroe County is shown a jar of glass sand. This mineral has been but recently discovered, and is said to be of a very superior quality. A glass manufacturing firm from Pittsburg, Pa., have removed to Michigan to work up this sand.

In the archæological department of the Michigan exhibit are shown a very large collection of stone implements and weapons, including flint spades, stone hatchets, hammers and axes, pestles and mortars, Indian totems or idols in the forms of lizards, otters, frogs, etc.; black, gray and red stone pipes, stone celts, stone lance heads, a large number of arrow heads and spear points; fish-spear heads with barbed points; sling stones, stone gimlets and awls. There are also several Indian skulls, and an Indian etching and painting on stone, also copper awls, files, spades, vases, and many other curious objects.

Missouri.—The mineral exhibit of Missouri consists largely of Galena and iron ores. There are some fine specimens of cerusite and pyromorphite; also, a fine display of zinc ores, calamine, Smithsonian and blende.

Galena is shown from Joplin, Granby and St. Joseph, very rich in metal.

Specimens are also exhibited of hematite, banded specular, red ochre, micaceous, red oxide, manganiferous and magnetic iron ores. Samples of iron in pigs and blooms are also shown.

There is a very interesting collection of fossils, including wood, shells, and ferns.

From Adair County and St. Louis County are shown specimens of bituminous coal.

Fine specimens of potters' clay are also shown.

There are some fine specimens of pyrites on joplin and some beautiful amethysts and quartzes. The Hannibal and St. Joseph Railroad Company make quite a large display of the mineral and vegetable productions of the country traversed by their road, consisting of wood, grain, coal, iron ore, etc.

Ohio.—The Ohio mineral exhibit is very large and complete, and gives a very fair iden of the wealth of the State. It embraces in the first place a large and beautifully executed map of the State, presenting besides the geological features, vertical sections of the principal coal and iron districts, showing the succession and depth of the various strata and the location of the various coal mines, iron mines, iron furnaces, petroleum wells and salt works of the State.

Near the map is a huge block of coal, 12 feet 8 inches in height, and weighing 10½ tons, from the mine of the Hurd Coal and Iron Company, at Ferrara, Perry County, in the Hocking Valley. Flanking this is a block of coal containing 2½ tons, mined by the Steubenville Coal and Iron Company, and on the other side a specimen of splint coal from the Cambridge mine in Guernsey County. There are also masses of Brian Hill or block coal from the Mahoning Valley, and a specimen of the Mineral Ridge coal and black-band iron ore, contributed by the Mahoning Valley Centennial Association. There are also specimens of coal from the mines of the Cherry Valley Iron Company at Washingtonville, and another from Macksburg.

The geological map shows hundreds of iron furnaces, scattered from the Ohio River to Lake Erie, in the eastern portion of the State, and specimens of the iron produced at many of these are exhibited by the Ohio Agricultural and Mechanical College. Besides these there are exhibits from the Youngstown region, embracing iron for the manufacture of Bessemer steel, and other kinds, made, some from Lake Superior ores, and others from the black-band ores of the Mahoning Valley, and the red hematites of several localities.

The Marietta, Pittsburg and Cleveland Railroad Company exhibit a fine collection of coal and iron ores from the line of that road, including besides the Cambridge and Macksburg coal, specimens of kidney and red hematite ores, and a mass of black band iron ore over seven feet high, and weighing nearly 9000 pounds, taken from the mines at Stone Creek, Tuscarawas County. This ore contains by analysis 50.68 per cent of carbonate of iron. The Glasgow Port Washington Iron Company also exhibit a large glass case containing specimens of pig iron made from black-band ore.

The Ohio River Coal and Salt Company exhibit a pillar of coal, and jars of fine and dairy salt, from their mine and works at Pomeroy, Meigs County. Sixteen million bushels of this coal are mined annually, six millions of which are consumed in manufactures on the spot. In a circle of seven miles around Pomeroy are 26 salt furnaces, 13 in Ohio and 13 in West Virginia. The brine from which the salt is made is obtained from about 100 artesian wells, varying from 1000 to 1400 feet in depth. The capacity of these furnaces is ten million bushels of salt annually: the actual amount manufactured is near seven millions.

The Central Ohio Salt Company, of Columbus, also exhibit some specimens of fine dairy and pork packers' salt from their works in Athens County.

A specimen of bromine from the Pomeroy Bromine Works is also exhibited. This bromine is made from the bittern or mother liquor of the brine from the salt wells, after all the salts separable by crystallization have been removed. Bromine is used in the manufacture of bromide of potash and other alkaline bromides used in the practice of medicine.

The Kokosing Oil Company, of Gambier, Ohio, exhibit a specimen of lampblack manufactured from natural gas. The gas flows from a well, over the mouth of which is placed a hood. The gas is lighted and the lampblack collected on the interior of the hood.

There are also exhibited specimens of the fire clays and limestones of the State, with pottery and fire brick, including a fine dentist's furnace. There are a number of specimens of lime accompanied by the limestones from which they have been burnt. There are some fine small grindstones and also some large grindstones on the platform outside the building from the Amherst quarries, and within specimens of building stones from the same quarries. There is a very large and fine collection of building stones of many varieties from all parts of the State, marked to show the geological formations from which they are taken.

The archæological exhibit of Ohio adjoins the mineral exhibit. It is contained in some fourteen glass cases, of mound-builders' remains and Indian antiquities, contributed by the Ohio State Archæological Association, and by a number of private gentlemen. Among them are many curious "maternity figures," rude images of brooding birds, which were worn on the heads of women with child; paint mortars, some of them still showing marks of paint; pestles, beads, carvings on stone of various birds and other objects; and a beautifully finished axe of rose quartz. The display of arrows and spear heads is very complete, a large number of the arrow heads have serrated edges, and many are twisted or rifled to give the arrow a revolving motion in the air.

The exhibit of grooved stone axes is very large; they vary but little in pattern, but considerable in size, the largest specimen weighing sixteen and a half pounds. The exhibit of flint drills, rimmers or borers, whether for drilling in stone or merely perforating leather, is also very large. The series of pipes is a very attractive feature of the collection, which contains many rare specimens, both of Indian and mound-builders' make. There is a very curious circular disc of stone, recently found near Circleville, Ohio. It is about a foot in diameter, and is carved with figures of two entwined serpents. The celebrated Cincinnati tablet is also exhibited, a small rectangular tablet of stone, carved with curiously shaped figures. It was taken from a large mound in Cincinnati in the year 1842. Near it was also found the major portion of a human skull, and also marks of fire. There are also four human teeth with small pearls set in the side, found in Indian graves, also hardened copper awls and deer-horn awls for sewing leather, found in a stone mound at Brighton Hill, Cincinnati, and hundreds of other extremely interesting objects. There are also large drawings of the track rocks of Ohio, showing in the solid rock the tracks of men and birds, and in one the track of a human hand. A map of an ancient earthwork at Newark is also shown. It is about a mile and a half long by a mile wide, and displays great engineering skill.

Wisconsin.—The State of Wisconsin has the lowest of the geological formations, the Laurentian. There is no coal in the State, as the carboniferous formation does not extend over it. In the Laurentian formation is found kaolin, or porcelain clay, fine specimens of which from Grand Rapids are shown. The exhibits of this State are so arranged as that the products of the various geological formations follow each other in regular order, commencing with the lowest.

In the Huronian system are found quartz, several fine iron ores and copper ores, in a belt about four miles wide and two hundred miles long, across the State. Specimens of these iron and copper ores are shown.

There are also specimens of rare fossils, found in the Potsdam sandstone, among them the lingula, the only specimens of which, in the world, were found at St. Croix. In the Potsdam sandstone is also found good iron ore, of which samples are exhibited. Rare fossils from the Wenton limestone formation are also shown.

The Galena limestone formation is 250 feet thick, and has produced, in Wisconsin, between seventy and eighty million tons of lead. There are specimens of these lead ores on exhibition.

Among the building stones exhibited are some beautiful red, chocolate and gray granites, which take a fine polish equal to the Scotch granite; also a very handsome Lake Superior brown sandstone, and several handsome limestones.

There are also on exhibition specimens of zinc ores, in which the State is quite rich, and also some large blocks of fossiliferous iron ore.

In the Wisconsin archæological collection are between two thousand and three thousand specimens of stone hammers and axes, a number of human bones and specimens of pottery of the mound-builders, a number of maternity stones, and a fine collection of pipes. There are also 165 pieces of pre-historic copper articles, said to be the largest collection of the kind in the world. They are principally knives, spears and fish spears. A collection of flint arrow heads and shovels is also shown.

Iowa.—The geological formation of Iowa is shown in twelve glass cases, the material of each of the strata being shown and the thickness stated in figures. There is a fine collection of building stone, consisting of granite, limestone, and marble of good quality. The Mahaska Coal Mining Company exhibit a pillar of coal 9 feet 5 inches high, and of fine quality. In a glass vessel is shown a specimen of peat from Chickasaw County, where it exists in a stratum four or five feet thick. There are samples of very fine red and yellow ochres, and also some very rich lead ore. Coal from Des Moines, where the stratum is six feet thick, is also shown. There is a remarkably fine collection of geodes or nodules of stone, which on being broken open show a hollow, with a lining of brilliant quartz crystals. These are from the vicinity of Keokuk.

A most curious object in the Iowa collection is a large stone, supposed to be a portion of a petrified human body, which was found embedded in clay at Ottumwa. It resembles the back of a man, extending from the neck to the end of the spine, and is 37½ inches long. An average size man measures 27 to 28 inches in that portion of the body, so that if this is really a portion of a prehistoric man, "there were giants in those days." A small but interesting collection of mound-builders' relics is also shown, consisting of human skulls, pottery, stone and flint implements.

Indiana.—The exhibit of Indiana consists principally of coals, among which are some remarkably fine specimens of cannel coal; there are also coking coals and block coal. From Washington, Daviess County, is shown a very large block of bituminous coal.

Specimens of iron ore and coke are also shown, and also iron rails of domestic manufacture.

Kaolin or porcelain clay is exhibited in large quantity, and from many different portions of the State. Hindostan oil stone, from which hones are made, is also exhibited in large blocks and of various degrees of fineness.

Diamond stone paint, a mineral paint of several colors and very hard, is exhibited.

Among the building stones is a marble of a very odd gray color, some sandstones of good color and grain, and several limestones.

Fire-brick clay and potter's clay is also shown, and also specimens of pottery, bricks, etc., made from the latter. Large blocks of shoe rubber sandstone of fine quality is also exhibited.

Delaware.—The exhibit of the State of Delaware is contained in a small enclosure about fifteen feet square. It consists of samples of iron ores, kaolin, granite, calcareous spar, marble and mica. The specimens are so arranged as to be very easy of access and examination.

Vermont.—The only exhibit from this State is a very large and beautiful block of white statuary marble from Rutland. On the front of the block an eagle is sculptured, to show the brilliancy and fineness of the grain.

Kentucky.—The exhibit from the State of Kentucky is in the east end of the south building, next the Elm avenue fence. It is entirely the result of a recent geological survey of the State. All the articles exhibited are careful averaged samples, and the analysis by the State chemist is affixed to each specimen.

Several specimens of iron ores are shown, together with the bituminous coal that is found in the same formation and in close proximity. Of cannel coals there are a great variety, some of them remarkably pure and rich in volatile elements, burning freely without crackling, and leaving but a small percentage of ashes.

Specimens of the soils of various portions of the State are shown. They are cut out in blocks about a foot square, and deep enough to show the subsoil and top soil. The underlying rock is also shown, and the analysis of the soil and rocks attached to the exhibits. Above are hung photographs showing the scenic appearance of the farms from which the specimens are taken.

Specimens of marl containing five per cent of potash and very rich in phosphoric acid are also shown.

Several varieties of building stone are exhibited, nearly all limestone, although there are one or two very handsome sandstones. There is also a specimen of very fine-grained stone from Elizabethtown, Hardin County, which, it is said, is fine enough for lithographer's use.

Several specimens of fire clay are shown. Also specimens of paint earths from Frankfort.

A sample of fine table salt from Meade County is exhibited. At the well where it is made the brine is forced up without pumping by a flow of natural gas. This gas is collected in a receiver and used for fuel, thus making the cost of producing the salt extremely low.

Fine specimens of fluor spar, very white and handsome, and some very rich lead ores, are shown.

Some fine specimens of the remains of the bison, or American buffalo, are shown, among them the skull of an extinct and unknown species.

One of the most interesting objects in this collection is a human body, thoroughly desiccated and perfectly preserved. It was found in a cave near Glasgow Junction, Edmonson County. The air of the cave is impregnated with nitre, and is perfectly dry. The body lies on its side, with the knees drawn up and the arms crossed upon the breast; it is partially embedded in the clay, and has been brought away just as it lay, without destroying the earth in which it lies. Near this body were found cloths and sandals made of a vegetable fibre.

A handsome collection of the Upper Silurian fossils is also shown, and a number of photographs of the interior of the Mammoth Cave taken with the aid of a magnesian light.

The Selma, Rome and Dalton Railroad Company make a fine exhibit of iron ores, iron, coal, coke, charcoal, etc., from the line of their road; also manufactured iron, car wheels, etc.

Tennessee.—The exhibit of Tennessee is dumped in heaps on the floor of the building, with but little attempt at order or arrangement. It consists principally of iron ores, nearly all hematites, from various portions of the State, together with fire clay, some excellent bituminous coals, coke, etc.

Virginia.—The exhibit from this State seems to be almost entirely by the Mineral Bureau of Virginia Railroads. There are some very fine roofing slates from Buckingham County, which seem to be equal in quality to any in the Exhibition. There are a number of specimens of iron ore from various portions of the State, and also coal of different kinds and qualities. There is a sample of shell marl—valuable as a fertilizer—from a point on the James River, near City Point. Also, a number of stalagmites and stalactites from Weyser's Cave. Also, several specimens of limestone, some white marble from Loudon County, and some beautifully veined bright-colored red marble from Orange County.

Alabama.—The geological formation of the coal and iron-producing sections of Alabama is shown in boxes. The material of the various strata are shown in their proper relative positions, and the thickness of the strata is stated in figures.

The above complete the State collections on exhibition in the mineral annex. In addition to the articles mentioned therein are a number of individual exhibits. Rowland & Sprogel, of New York, exhibit artificial stone; the Pittston Coal Company, of Randolph County, West Virginia, exhibit a sample of coal; Wm. Bell, of Smyrna, Delaware, exhibits porous drain tile; F. R. Albert, of New York, exhibits composition pipe and artificial stone; George Richardson, of New York, exhibits carbonized stone and pipe; the Union Mining Company, of Allegheny County, Maryland, exhibit the Mount Savage fire-brick.

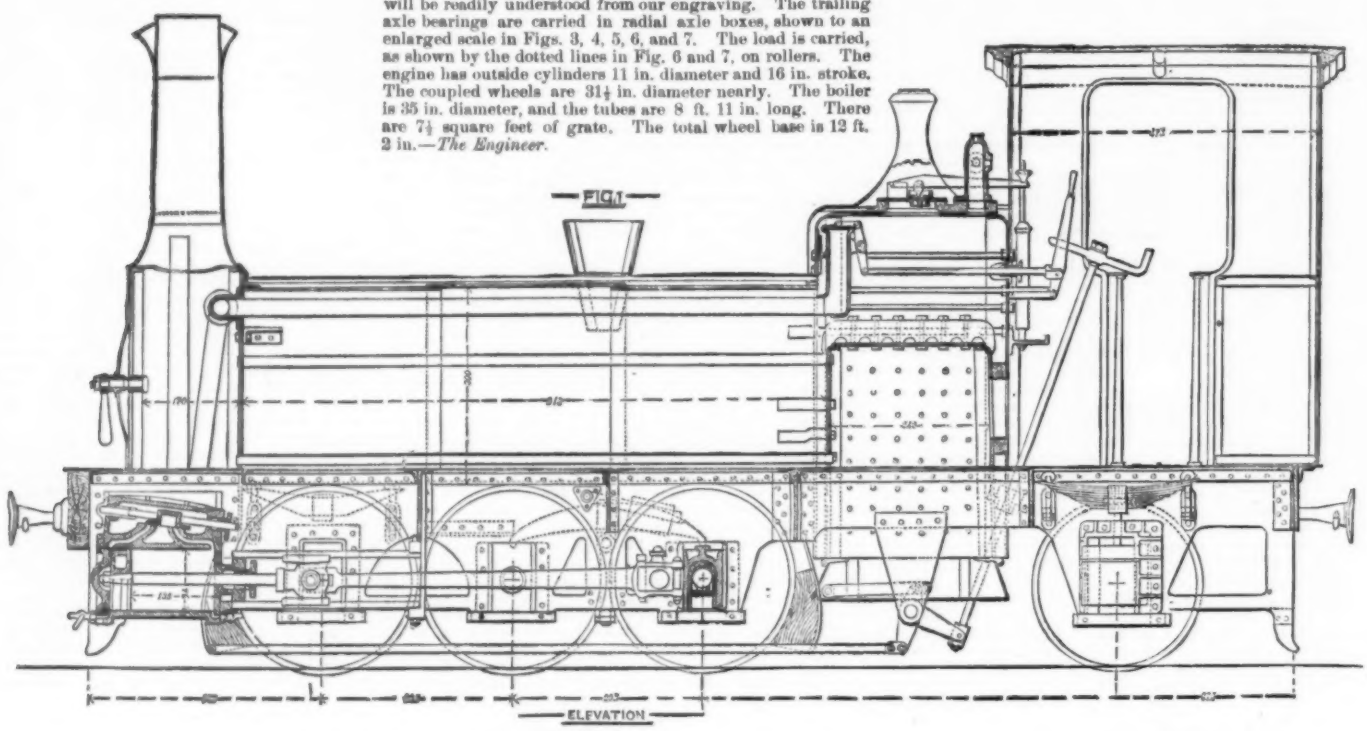
J. M. Bruce, of Boston, exhibits the Vesper street lamp post. B. Kreischer, of New York, exhibits fire-brick and fire-clay retorts. The Howe's Cave Hydraulic Cement Works exhibit the cement rock and also the cement in barrels. The Anthracite Fuel Company, of Rondout, N. Y., exhibit fuel made of coal dust. Isaac Ogden, of Newark, N. J., exhibits vitrified drain pipe. William Scattergood, of Rancocas, N. J., exhibits porous drain tile. N. U. Walker, of Cliff Mine Terra Cotta Works, Wellsville, Ohio, exhibits drain pipe; and M. Ehret, Jr., of Philadelphia, exhibits granulated slag roofing.—*Philadelphia Ledger.*

SHIP CANAL BETWEEN THE ATLANTIC AND PACIFIC.

THE Nicaraguan route for an inter-oceanic ship canal between the Atlantic and Pacific Oceans has been determined upon as most feasible. The estimated cost is $65,722,137, but several practical engineers who have examined the route express the opinion that the many obstacles to be encountered will increase the cost to nearly one hundred millions. At least five years will be required to complete the canal, and should it be constructed under the control of leading Governments it is believed the work would not be delayed for want of funds to prosecute it. The total length of the canal by the Nicaraguan route will be about sixty-one and three quarter miles. To this is to be added sixty-three miles of slack-water navigation by way of the San Juan River, and fifty-six miles across Lake Nicaragua, making a total distance from ocean to ocean by lake, slack-water navigation, and canal of about 180¾ miles. The proposed canal will have ten locks in the western division, between Lake Nicaragua and the Pacific, including a tide-lock at Brito on the Pacific coast, to admit ships at any stage of the tide, each lock having a lift of about ten feet. In the eastern division, between Greytown and the mouth of the San Carlos River, seven locks will be required. From the mouth of the San Carlos River to Lake Nicaragua the navigation of the San Juan River is entirely practicable with the three short sections of canal, each having one lock at Castilla, Balas, and Machuca.

TANK LOCOMOTIVE AT THE EXHIBITION.

We illustrate a Swedish locomotive, constructed for the metre gauge—3 ft. 3⅜ in. The general features of the engine will be readily understood from our engraving. The trailing axle bearings are carried in radial axle boxes, shown to an enlarged scale in Figs. 3, 4, 5, 6, and 7. The load is carried, as shown by the dotted lines in Fig. 6 and 7, on rollers. The engine has outside cylinders 11 in. diameter and 16 in. stroke. The coupled wheels are 31½ in. diameter nearly. The boiler is 35 in. diameter, and the tubes are 8 ft. 11 in. long. There are 7½ square feet of grate. The total wheel base is 12 ft. 2 in.—*The Engineer.*



THE INTERNATIONAL EXHIBITION OF 1876.—NARROW-GAUGE SWEDISH TANK LOCOMOTIVE.

PEYER'S STEAM-TRAP.

WE subjoin an engraving of a form of steam-trap designed by Mr. Alfred Peyer and constructed by Messrs. Schmerber Brothers, of Mulhouse, this trap being arranged so as to discharge both air and water automatically. The apparatus consists of two chambers connected by a short pipe, at the bottom of which is a valve-face fitted with a partially rotating valve, as shown on the plan. To an arm on this valve is coupled one end of a bent tube filled with liquid and hermetically closed, the other end of this tube being fixed as shown.

Fig. 1.

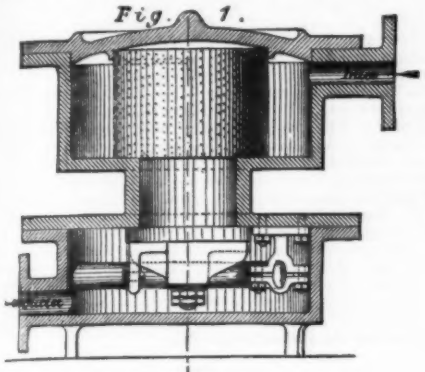
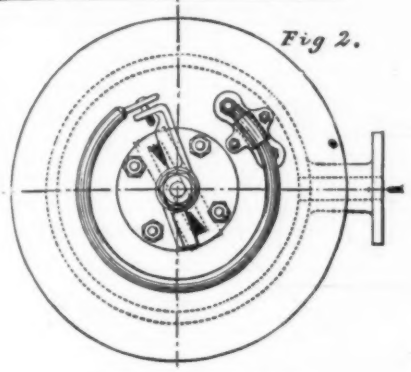


Fig 2.



PEYER'S STEAM-TRAP.

It follows from the arrangement adopted that if the bent tube be heated the liquid in it will expand, and so cause the partial uncoiling of the tube, this uncoiling movement partially rotating the valve and causing it to close the openings. The upper vessel, it will be noticed, is fitted with a screen, to keep dirt from getting to the valve, and to this chamber the pipes to be drained of water, etc., are connected.

The action of the apparatus is as follows: When steam is not admitted to the pipes or vessel to which the steam-trap is connected, the bent tube is of course cold, and the valve is entirely open. If now steam be turned on, the air will first be discharged from the pipes, and then there will be a greater or less flow of water of condensation. This water being warm, the liquid in the bent tube will be expanded, causing the valve to be rapidly closed. When, however, the water thus discharged has run out of the lower vessel, the external air enters and cools the tube, causing the valve to be again opened, and so on. The apparatus is simple, and, we believe, acts promptly.—*Engineering.*

NEW STEAM CONDENSER WITHOUT AIR-PUMP.

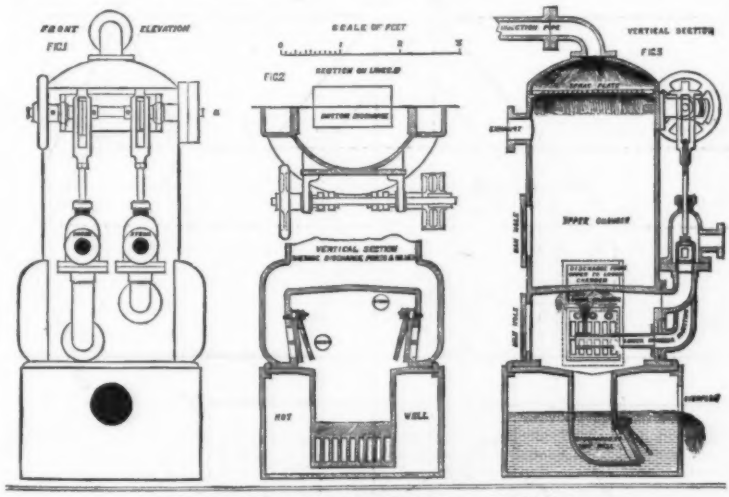
AT the recent meeting of the Institution of Mechanical Engineers at Birmingham, a paper "On McCarter's Condenser without Air-Pump, for Steam-Engines," was read by Mr. Francis Preston, of Huddersfield.

The air-pump and condenser combined, in 1765, by either James Watt or Gainsborough, and successfully introduced by James Watt, have undergone very little modification since they first left his workshop. The few alterations that have been introduced have in no essential altered the principle or general arrangement. Many attempts, with varied success, have been made to introduce a condenser without an air-pump. The writer believes there has been no successful application of a condenser without the aid of an air-pump, and capable of lifting its own injection-water, previous to the one now forming the subject of this paper.

The late John McCarter, of Londonderry, was the inventor of the condenser that forms the special subject of the present paper, and he made further improvements in subsequent years for perfecting his original invention. Unfortunately he has not lived to reap the merited reward of his beautiful and simple invention, having died last year, just at the time when his invention was beginning to be practically appreciated. McCarter's invention takes as a basis the ordinary condenser, and adheres pretty much to the present recognized proportion, admitting the exhaust steam and the injection-water in the usual way. To dispense with the air-pump is the object he had in view, and to substitute a simpler and less costly mode of discharging the water and air that continually accumulate in the condenser when at work, and at the same time be enabled to place the condenser in any position and elevation with respect to the cylinder that is found most convenient. This condenser draws its own injection-water from any depth as in the ordinary condenser, and, being enabled to work at any elevation, it can be so placed as to allow the waste water to flow back again to any desired level. The condenser is provided with a small auxiliary condenser placed at the bottom of the ordinary or condenser proper. This is worked separately and independently, and is connected with the ordinary condenser by two intermediate india-rubber foot-valves. These two intermediate india-rubber foot-valves are worked by means of forming a vacuum in the auxiliary condenser by introducing a separate jet of steam and water, supplied alternately by independent mechanical means, thereby alternately creating and destroying a vacuum about five times per minute. The act of making this vacuum enables the two intermediate valves to open, forming a connection with the condenser proper, thereby allowing the accumulated water to flow into the auxiliary condenser, and the destroying the vacuum by a jet of steam admitted into the auxiliary condenser causes the two intermediate india-rubber valves to close, and at the same moment opens the delivery valve in the hot well, thereby discharging the hot water and air, which flow away in the ordinary manner.

Fig. 1 is an elevation of the condenser, with the small auxiliary condenser and hot well complete, and ready for the connections. Fig. 2 is an elevation in section, showing the two foot-valves which connect the condenser proper and the auxiliary condenser; and Fig. 3 is an elevation in section, showing the independent water and steam valve in connection with the auxiliary condenser. C is the tappet shaft, giving motion to the two equilibrium valves. This shaft revolves about five times per minute, and is worked either direct from the engine or from any other convenient shaft. In Fig. 3 is shown the water-valve, which is connected with a supply of water at a higher elevation than the auxiliary condenser; and also the equilibrium steam-valve in connection with the boiler, from which it receives a supply of steam five times per minute. This jet of steam is diminished in pressure by a diminishing valve placed near the boiler, so as to give the jet of steam at an average of 3 lb. to 4 lb. pressure above atmosphere when entering the auxiliary condenser. McCarter's condenser draws its own injection-water in the same way as an ordinary condenser, and there are some at work successfully lifting their own water 22 ft. to 24 ft. vertically.

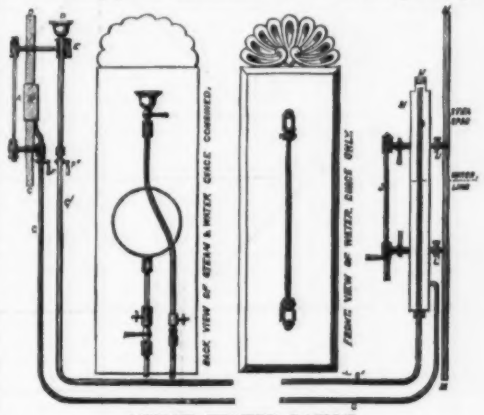
These condensers have now been successfully at work upwards of three years in conjunction with engines from 12-in. cylinders to 37-in. cylinders, and they are giving great satisfaction, effecting a considerable saving in coal—25 to 33 per cent—besides giving much steadier motion to the machinery, caused by the regularity of the working of the condenser, without the great strain being put upon the engine through the ordinary air-pump at every revolution of the engine. The power required to work the tappet shaft is hardly worth a consideration; and this shaft can be either worked direct from any convenient part of the engine or may be worked from any counter-shaft or other independent motive power. As an illustrati n of the successful application of these condensers, the writer would mention the first condenser introduced in Yorkshire, and which was applied to a compound horizontal engine, with a condensing cylinder 20 in. in diameter. This application was introduced in order to make the power previously absorbed in working the air-pump available for driving the engines three strokes per minute faster, with the same machinery thereon, and without any especial reference to economy. The result was stated by the proprietors of the mill to be that the engines have done more work in the mill than in any other month, with a regular speed and with greater ease, besides saving fuel in money value amounting to 33 per cent.—*The Engineer.*



STEAM CONDENSER WITHOUT AIR-PUMP.

NEW OFFICE WATER-GAUGE.

THE accompanying engraving shows a system of fitting water-gauges on boilers, oil-tanks, spirit-vats, etc., by which necting stand-pipe to gauge; H, stand-pipe attached to boiler; J, gauge-glass to ditto, ordinary fittings; K, copper return-pipe; L and L^1, cocks to cut off boiler connection; M, boiler-plate; N, cup into which the return-pipe enters. The tube being entirely filled with cold water to the water line in the stand-pipe, a glance at the drawing will show that the water in the stand-pipe and the return-tube K will always be upon



OFFICE WATER-GAUGE.

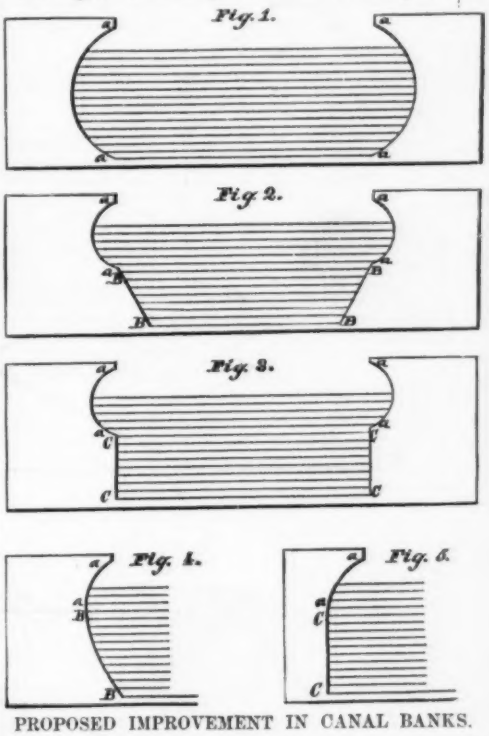
the same level. If the water falls in the stand-pipe, it will fall also in the pipe K, and the movement of the water falling in K being continuous throughout the entire tube, it causes the colored liquid at A to fall also; thus showing in the instrument the fall or rise of the water in the stand-pipe, and by that means continually indicating in the instrument the height of water in the stand-pipe, which, being attached as shown to the boiler, always gives the true level of the water in the boiler. Open tanks or cisterns do not require either the stand-pipe H or the pressure-gauge B.—*The Engineer.*

IMPROVEMENT IN CANAL BANKS.

By W. RODNEY, New-York.

THE object is to give the water in a canal a rotary motion, thereby avoiding the excessive wash over the bank. This is effected by my invention of a concave canal wall. By thus decreasing the height of the following wave and protecting the bank, the speed of the boat or vessel may be increased and transportation facilitated.

The degree of concavity of the canal wall may be deter-



PROPOSED IMPROVEMENT IN CANAL BANKS.

mined by the width and depth of the canal, and the speed of the boat or vessel used.

This form of wall may be applied in several ways, as shown in the transverse views of the accompanying drawings, Fig. 1, *a a*, where the entire wall is concave; Fig. 2 and Fig. 4, where the concave wall *a a* is placed on an outward-sloping wall, B B; Fig. 3 and Fig. 5, where there is a vertical wall, *c c*, with the upper part *a a* concave.

The concave bank may be used also on one side only of a canal where the other is a vertical outward-sloping, a natural bank, or of any other configuration.

RUSHES.

IN an interesting article on rushes, a contributor to the *Gardeners' Chronicle* points out that the plant has really rendered considerable service to commerce. The canals or water-ways constructed by the Duke of Bridgewater owed much of their stability to the rushes that were planted all along their banks, and particularly on the towing-path side, where the fringe of rushes saved the rope from fretting; in short, the plant seemed essential to the canal, for its toughly matted roots bound the banks firmly, and formed the crowning sod, making an elegant fringe, as useful as if it were made of hewn stone. Unlike the working of any shrub or tree that would outgrow its place in a year or two, the rush retains its evergreen wisps to all appearance for ever; and hence we see Brindley's rushes little more than a foot high after a generation of boatmen have brushed their tops ten times a day.

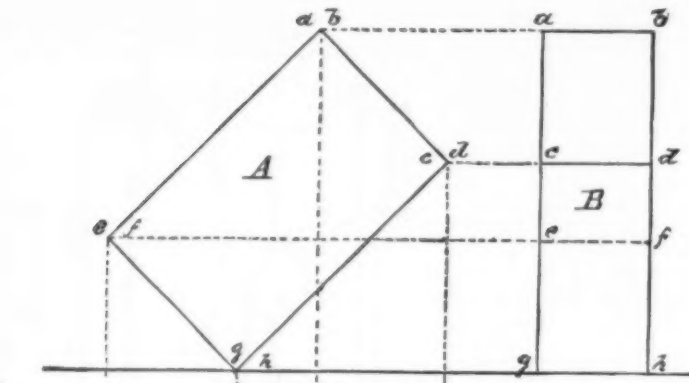


Fig. 186

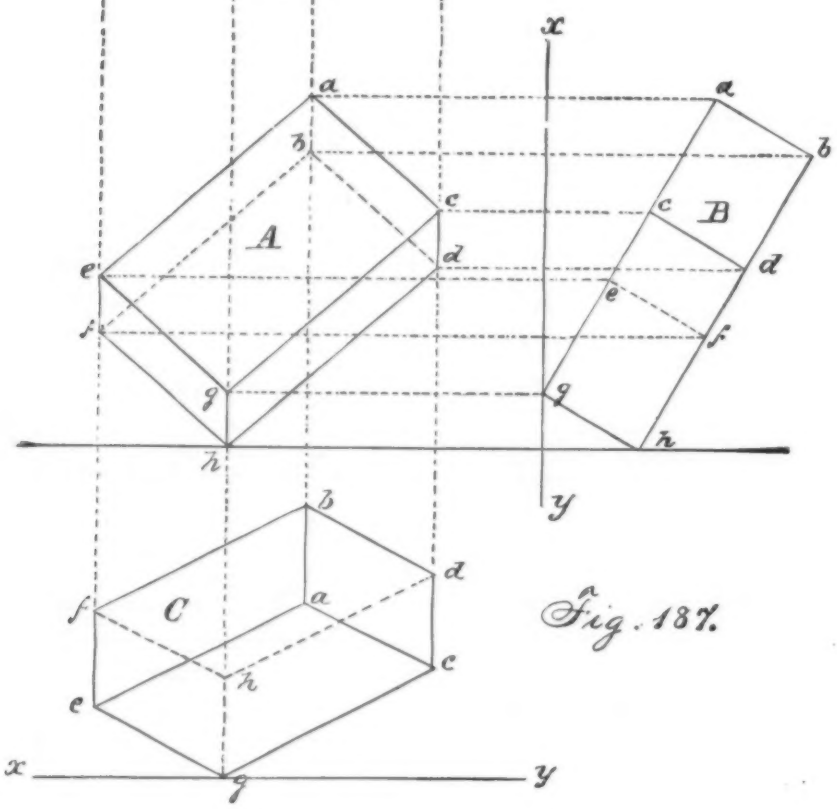


Fig. 187.

LESSONS IN MECHANICAL DRAWING.

By Prof. C. W. MACCORD.

No. XXII.

(Continued from page 636.

RESUMING now the consideration of projections, it will be recollected that we have explained a method of constructing, from the drawings of a body made when placed in the most simple relation to the paper, the projections of the same body when changed into a new position. Also that this change from the old position to the new was effected by revolving the body about an axis which was perpendicular to the paper in some one of the three original views: such revolution not changing that view, and leaving also unchanged one of the two sets of dimensions in the other views.

The relations between these three axes, about which the body is supposed to revolve, will be clearly seen on examination of Fig. 185, in which A, B, C respectively represent the faces parallel to the paper in the front, side and top views of a cube placed in the simplest position; and *l o*, *n o*, *m o* are the axes perpendicular to those faces. These axes are therefore perpendicular to each other, and we introduce the figure for the purpose of clearly impressing this relation on the mind, because it is important to remember that this is always the case in the method of operation which we are now considering: it does not matter whether the body be placed in this position or not, nor in fact how it is placed, so far as changing from the first position to the second is concerned, but that change is made by revolving it around one of these three axes in the manner explained.

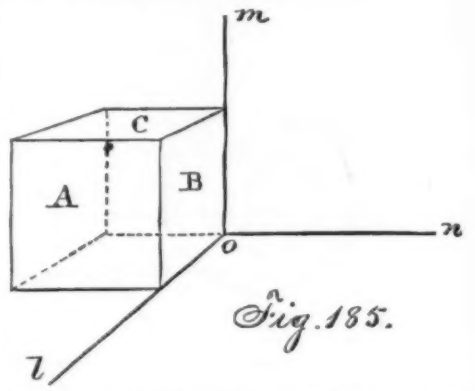


Fig. 185.

Now, we think, it will be easily seen that if we have an object in the original simplest position to start with, we may revolve it around one of these axes first, and then around one of the others. The change from the second position to the third involves no new principle at all; we have full information in regard to the body in its second position, and, that being so, we may deal with that drawing exactly as though it were the original and indeed the only one.

Thus, in Fig. 186 we give a copy of Fig. 169, which represents our parallelopipedon of Fig. 144 after revolution about the axis *l o* of Fig. 185. Let us next revolve the body about the axis *n o*, which is perpendicular to the paper in the side view.

As before, in doing this the side view undergoes no change, and all we have to do is to copy it in its new position, as in Fig. 187. It is now to be recollected that this revolution does not change the breadths in the front view, and they are therefore to be simply transferred from the front view in the original group. In order to exhibit this more distinctly, we have placed the front and top views of Fig. 187 directly under those of Fig. 186, so that these breadths may be transferred by merely dropping perpendiculars with the triangles.

As for the heights in the new front view, they are the same as in the new side view, which we have just drawn, so that the position of the projection of a point in the front view is found by dropping a perpendicular through its projection in view A above, and intersecting it by a horizontal through its projection in view B below. Corresponding points are similarly lettered throughout, so that this operation can be readily traced without explaining it step by step at greater length, especially since the guiding lines are dotted in.

From these two views the third, or plan view, is constructed

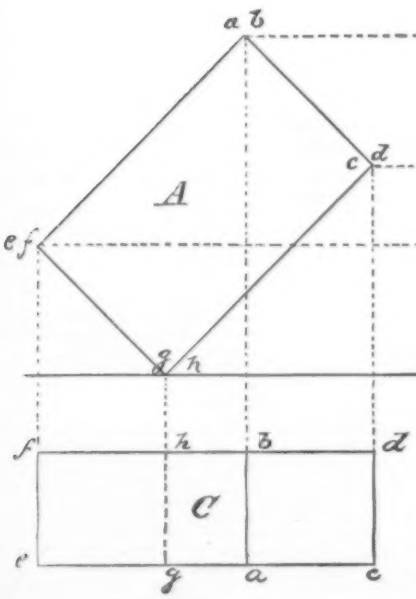


Fig. 188.

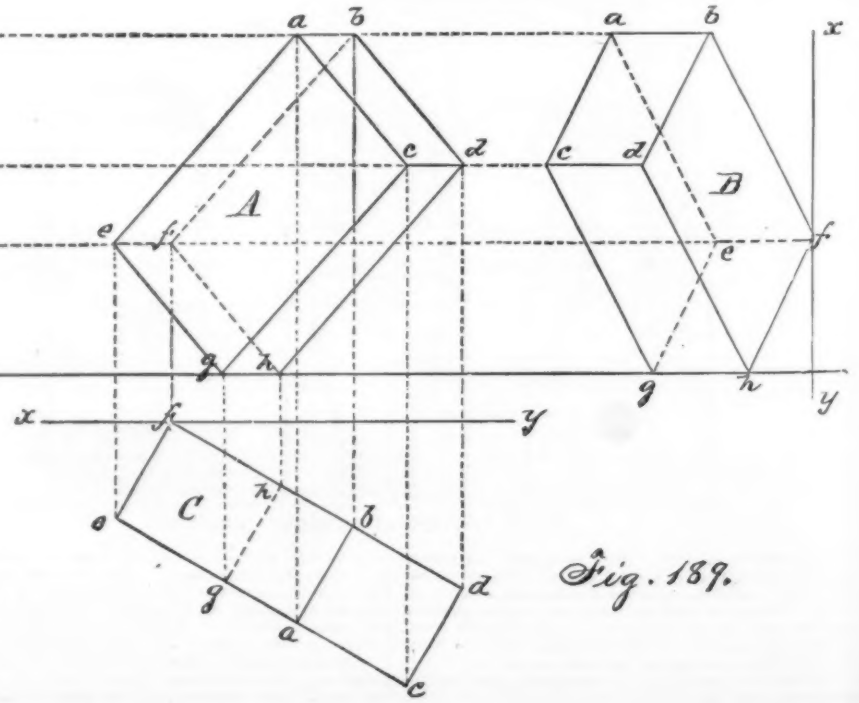


Fig. 189.

in precisely the same manner as in any other case. We see that g is the extreme front point, that is, the one nearest the observer, and b the most remote one; and if a vertical plane be supposed to pass through g, it will appear as a line, $x\,y$, whether we look at it from the side or the top. Drawing such a reference line, then, we merely set off from it vertically in the top view the horizontal measurements from it to the various points in the side view, taking care to place the projection of each one directly under its projection in the front view.

Now, instead of revolving the body around the axis $n\,o$ of Fig. 185 as the second step, we might have turned it about the vertical axis $m\,o$. Had we done so, as we have seen before, the appearance of the object as seen from *above* would not have been changed, nor yet the height of any point. That is to say, we would have been able to make this change by copying the plan view in a new position, and to construct the front view by transferring the altitudes from the preceding group. Thus, Fig. 188 is identical with Fig. 186, and is repeated merely for the sake of showing the order of procedure more clearly. Since the revolution about the vertical axis does not change the plan view except in position, we copy it, as at C of Fig. 189. In the new front view, the projection of each point will be perpendicularly over its projection in the view C, and at the same height as that of its projection in the original front view A of Fig. 188. In other words, if the two drawings, or groups of views, are placed with reference to each other as here shown, we have only to draw a horizontal through any point, as for instance d, of the view A or B of Fig. 188, and intersect it by a perpendicular through the corresponding point of the view C of Fig. 189, to find the projection of that point in the new front view which we are constructing. All of which we think will be readily traced by the aid of the guiding lines, each point being designated by the same letter throughout. And by this time it ought to be superfluous to go into any details of the construction of the third view from the two thus made. At any rate, if it is not superfluous it is useless for another reason, and we accordingly leave the figure to speak for itself.

We see then that the object, supposed to be originally placed as in Figs. 144, 164, 168, and 173, is brought into the position shown in Fig. 187, by two revolutions, the first about $l\,o$, the second about $n\,o$, of Fig. 185.

Now it might at first thought appear that the same result would follow, if we were to revolve the object first about $n\,o$, and afterwards about $l\,o$. This, however, is not the case. Certainly, there is nothing to hinder our proceeding in that order; but the position thus given the object will not be the same, as will be seen from Figs. 190 and 191. We have here the same rectangular prism, and the lettering is the same as in the preceding figures, which will enable the student readily to follow the steps of the process. The top views are omitted, but it will be at once seen by comparing the two views of Fig. 191 with the corresponding ones of Fig. 187, that the positions of the prism are not the same.

And the reason will be seen when it is observed that in making the first revolution about $l\,o$, in Fig. 186, the point g does not move with reference to h, as seen in the front view; but when the prism is first turned about $n\,o$, in Fig. 190, g rises, and when the revolution about $l\,o$ follows as in Fig. 191, g does move relatively to h, as seen in the front view.

The student is advised to familiarize himself with not only the principles, but with the practice of thus constructing views of the different bodies which have been illustrated, in positions thus obtained by successive revolutions; taking first those which are bounded by right lines, and varying not only the angle but the direction of the rotation; not only this, but constructing views from the left as well as from the right, until he can perform these operations without difficulty, and read his drawings also. This last injunction may appear absurd, as one may ask how one can write what he can not read. Nevertheless, it is not so impossible as it seems to be on its face: if the student should fall into the error, against which we have repeatedly warned him, of merely copying the figures given in illustration, or even of adopting in all cases the same arrangement of the views, he may be disagreeably astonished on making an attempt to introduce variations, by finding himself bewildered. And in any case, it requires some schooling of the imagination, and practical schooling at that, to be able to *read* a drawing in which objects are represented in these inclined positions with perfect readiness and certainty.

We do not by any means intend to say that in this kind of practice it is necessary that all the drawings should be finished: in fact, we would on the contrary say that it would be better, instead of taking the time to ink them in, to make a greater number in pencil merely: and in so far as the study of the principles is concerned, it will be found excellent practice to make freehand sketches. This will train the hand and the eye, and if care be taken to study out the reason why each point should be drawn in a certain position, trusting nothing to a study of the appearance of a model as a guide to the eye in locating the points, the mental training is as valuable as though the more laborious process of making correct instrumental constructions were always adopted.

This, however, is not to be taken as a hint that the latter may be neglected; it is simply meant to imply that such free-hand work, if faithfully and properly done, will facilitate the acquirement of principles and methods, which are intrinsically necessary to satisfactory progress.

Nor, on the other hand, do we intend to deprecate the use of a model, in a proper way. As an aid to the imagination, in tracing the relation between the projections and the object, the study of a model is of great value: it is not at all requisite that each one should resolve to make no plan or drawing but such as he can "evolve from his own internal consciousness;" if the student finds that from the start he is able to dispense with the model, and that his internal consciousness suffices to enable him to realize the relations between his drawings and the object, so much the better, as a matter of course; such an one is to be congratulated, because that realization is the proof of his possessing a power which must be acquired somehow, and may be legitimately acquired by any means. And one of the most efficient aids is the study of a model, especially in the beginning and in dealing with elementary subjects. But what we mean by not trusting to the appearance of the model as a guide to the eye in making the free-hand sketch as above recommended, is this: that as we are now engaged in the study of *projections*, care must be taken not to confound the appearance of the object to the eye, with that which the projections will present; and unless the student is continually on his guard in this particular, he will be very liable to fall into the error of sketching his model as he sees it, thus producing a perspective representation. We deem it necessary to speak of this at such length, because in the study of perspective, when we come to that, the use of the model as an aid to acquiring facility in that kind of drawing will be also recommended; and as the two modes of representation as well as the two modes of study are quite distinct, we are anxious to set this matter in as clear a light as possible; and the more so, because the perspective or pictorial representation is the one which seems the most natural, and an effort is required to avoid mentally connecting the model with a drawing of that kind.

We have already spoken of the fact that in many cases it is necessary or desirable to make sectional drawings of mechanical details, and have given one or two simple illustrations. The manner of proceeding to be followed when such drawings are to be made, might be left to suggest itself as occasion arose, and probably the student would be able in most cases to reason it out by careful combinations of, and deductions from, the general principles of projection, provided that he had fully mastered them in their application to the drawing of all kinds of objects and surfaces in full elevation. But it will be found not only more easy, but a great saving of time, to make this a sort of special study, and to acquire the principles which are involved by practice in the construction of sectional views of elementary forms. And to relieve the monotony which may render irksome a continuous discussion of the matter of projections involving the changes of position, which is not yet concluded, we introduce here an example or two of a different class of work, no less important and possibly more interesting in itself.

In Fig. 192, we have an upright hexagonal prism, which we will suppose to be sawn through in a sloping direction indicated by the line L L; the lower portion is shaded, the upper being shown in full lines, merely to distinguish the two parts from each other.

Now, this solid is one with which we are already well acquainted, so that nothing need be said about the drawing of the prism before it is cut; as soon as it is, we may remove the upper piece, and then the question will arise, What is the precise shape and size of the sloping cut?

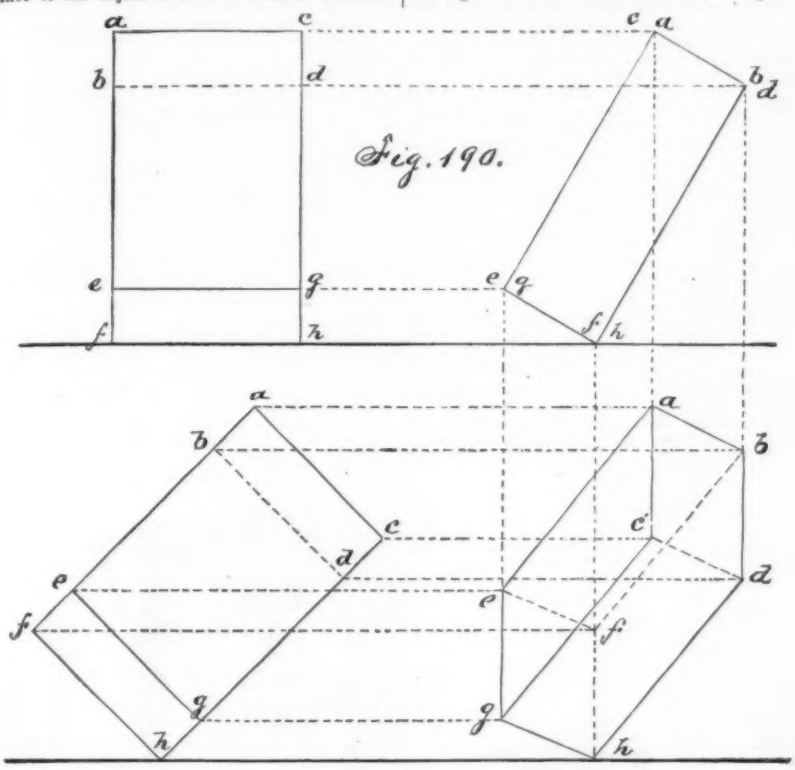


Fig. 190.

Fig. 191.

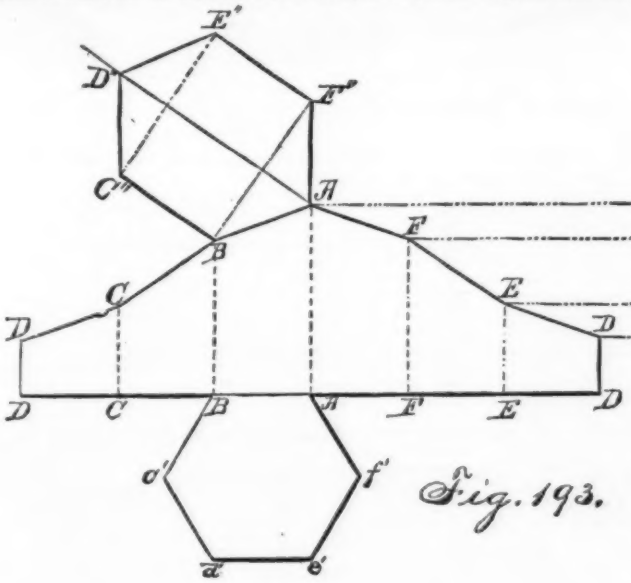


Fig. 193.

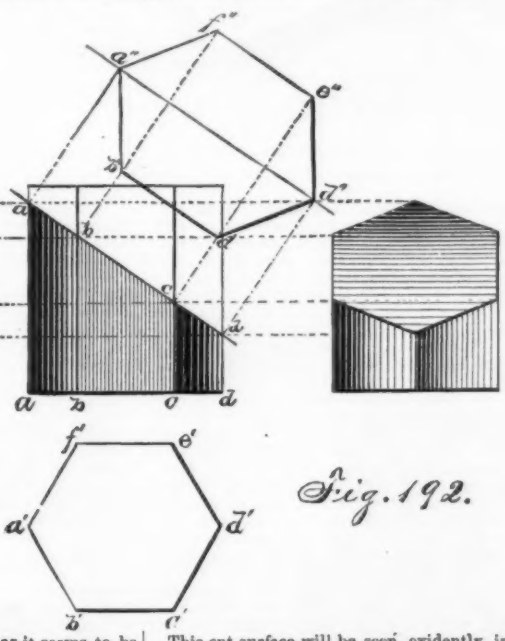


Fig. 192.

This cut surface will be seen, evidently, in the top view. If we suppose the upper piece of the prism to be removed; but it will appear simply as a regular hexagon, in no respect different from the upper base of the original prism.

It will also be seen if we construct a side elevation of the lower part; in this view the section will appear as a figure bounded by six right lines, but these lines will not appear of equal lengths, nor of their true lengths: we shall have, as shown, an irregular hexagon, but it is not as long, though it is as broad, as the section itself.

In order to see all the lines of this section in their true length and proper relations, we must look perpendicularly against the plane in which they lie, as shown by the arrow. In this case, the line $a\,d$ in the plane L L will appear as $a''\,d''$ in the view made in the oblique position, $a''\,d''$ being parallel

to L L. And in the section there is, clearly, a line, $b' f'$ in the plan view of the prism, which is seen perpendicularly, and therefore in its true length, whether we look down upon it vertically as in that top view, look at it horizontally as in the side view, or at an angle as in the inclined view which we are now making. Consequently, as this line is perpendicular to $a\ d$ in the sloping surface, it will be perpendicular to $a''\ d''$ in the new view, appearing as $b''\ f''$, its length being equal to that of $b'\ f'$. The same mode of reasoning is applied in finding the points c'', e''; and joining the six points thus determined by right lines, we have at last another irregular hexagon, which truly represents the form of the section of the prism.

Now, in the front view we see the exact form and size of the part of the face of the prism bounded by the vertical edges $b\ b$, $c\ c$. Were we to turn the object round, so as to place each face in succession parallel to the paper, we should have had a view of the whole surface—and by moving the prism sideways just the breadth of a face after each partial revolution, we may make a drawing showing the entire surface at once. This is exactly the same as though we were to imagine the prism to be made of thin sheet metal or other flexible material, and then cutting it lengthwise, were to unfold it into a plane. The form thus produced is shown in Fig. 193, and is easily constructed from the information given in Fig. 192. Thus, it will be seen that the lengths of the edges $a\ a$, $b\ b$, $c\ c$, etc., of the latter figure, do not change by the operation of unfolding the prism; and so the lines A A, B B, etc., of Fig. 193, which correspond to them, are of the lengths given, measured vertically from the base line D A D, which is drawn on the same level as the base of the original prism. The distances between these lines, as D C, C B, etc., measured on this base, are equal to the lengths $a'\ b'$, $b'\ c'$, etc., of the sides of the base of the solid in Fig. 192.

Now, joining the upper ends of the lines D D, C C, etc., by the lines D C, C B, etc., we have the representation of each face of the prism, in its true form and size, but not in its proper position in relation to its neighbors.

If we bend the sheet on the lines C C, B B, etc., however, we may restore the original relation; and by cutting out the figure in cardboard, and then cutting half through the substance along these lines, a very satisfactory model may be constructed. But to make it complete, the upper and lower bases must be added.

These may be cut out in one piece with the part forming the vertical faces; they may be attached to any one of those faces, in the manner shown in the figure, care being taken, when one of the bases, as in this case, is of an irregular form, that in copying the sides and angles in their new position, it is done in such a way as to introduce the least amount of error. The meaning of this caution may be made clearer thus, perhaps: if we begin by transferring the angle $a''\ b''\ c''$ to A B C', then setting off B C' equal to $b''\ c''$, and after copying this on the other side of the figure at B A F', proceed in like manner round the hexagon, we must not be surprised if the final lines do not meet at D', as they ought to. A better way in this case would be to determine D' first, by describing an arc about A, with radius $a''\ d''$, and another about B, with radius $b''\ d''$; then drawing a perpendicular to A D' through B, set off B F' equal to $b''\ f''$ in Fig. 192, and make B C', F' E' parallel to A D' and equal to $b''\ c''$: then when the figure is completed there will be a comfortable feeling of confidence in its resemblance to the original.

This process of unfolding the surface of an object, and spreading it out on one plane, is called *development*, and is of great utility, as we shall subsequently have occasion to show. But aside from this, we think that our readers will agree with us that it is an interesting application of the principles of drawing; and they will find it a profitable practice to follow the suggestion above made, laying out the diagram accurately, and then cutting it carefully to the outline (using moderately heavy cardboard for the purpose), and with a sharp knife cutting half way through along the lines by which it is to be folded; then gumming the edges which meet, the accuracy of the drawing will be tested by the regularity and perfection of the model thus made. We shall afterward give additional examples which may be treated in this way with pleasure and advantage to the student.

THE SEISMAGRAPH.

This instrument has for its object the record of shocks received by, or the oscillations produced in, any vehicle, such as a locomotive or railway carriage when in motion. It is the invention of Mr. H. Carlile, Memb. Inst. C. E., and managing director of the Dünaburg Vitebsk Railway, and has been designed by him chiefly for making periodical records of the state of the permanent way on that line. When used also on *different* vehicles run over the same portion of line, it also becomes a means of checking the relative steadiness of the motion of these vehicles, a use to which it can be applied with great advantage. Its action depends upon the inertia of a weight suspended in space by an elastic medium attached to a point of support. If such point be shifted suddenly in any direction, the suspended body, from its inertia, retains for a moment its original position—after the point of suspension has been shifted—and only gradually takes up the new position due to it through the alteration in the position of the point of support, but with an amount of force varying according to the distance through which, and the velocity with which, the point of suspension has been disturbed.

If by means of a mechanical arrangement this force be rendered available for moving a pencil at right angles to a straight line, which the pencil, when at rest, is describing on a strip of paper, the pencil will make a corresponding mark, and there is at once a record gained of the movements of the point of support referred to. It is only necessary then to attach the point of support to the vehicle, the oscillations of which are to be investigated; and to provide that the strip of paper shall travel at any certain rate, corresponding either to that of time, by means of clockwork, or to that of the velocity of the movement of the vehicle, by means of an arrangement put in motion by the wheels of the vehicle, and a diagram will be formed, which not only shows the various oscillations of the vehicle, but points out the time when, or the place where, such oscillations took place.

Our engravings, Figs. 1 and 2, represent two perspective views of this instrument taken from opposite corners. The instrument is generally carried in a strong box, to the bottom of which it is firmly fixed, but which has in this instance been removed, so as to expose the instrument completely to view.

A is a strong cast-iron plate, about 13 in. by 12 in. in size, which forms a base upon which the different parts of the instrument are fixed, and which can be screwed to the bottom of the box above referred to; B, a firm upright of cast-iron firmly screwed to the base-plate A; C is a brass cylinder containing a mass of lead, and attached to a light brass barrel D. This barrel is suspended at one end by means of a strong ring Q riveted on to it, which works in the universal joint E, the four screws forming the axes of wheels which are shown at F. The weight C and the barrel D are turned true to one axis, and have another point of support at G, where, through means of a pin fixed in the weight and carrying a cross-lever, to the ends of which are attached the spiral steel springs H, which again are hung from the end of the straight steel spring I, attached firmly by means of four adjusting screws K to the upright B, the weight and barrel are suspended, so as to be free to move in any direction round the universal joint at E. In the centre of the weight, and firmly attached to it, is a projection L (Fig. 1), furnished with a hole extending into it, in the line of the axis of the weight and barrel. This projection moves with the weight, but limits its movement by means of the metal ring M, within which the projection plays, and which is concentric with the axis of the weight when the latter is at rest.

The ring is firmly attached to the base-plate A. The amount of play it allows to the weight is about 1¼ in. in every direction from the axis, and which is sufficient for showing oscillation of ordinary character. At N there is a strong pin attached to the end of a short lever, which, by means of the spindle O and the handle P, can be inserted into the hole in the centre of the projection L, so as to lock the weight, and prevent any movement in it when the instrument is not being used.

In Fig. 1 the weight is at rest, but in Fig. 2 it has been depressed, so that the projection (L in Fig. 1) is in contact with the lower part of the ring M. The ring Q (Fig. 2) is turned out at the end remote from the weight C, so as to form an annular flat surface of about ½ inch in width, and 2½ inches outside in diameter. When the weight is in its normal position of rest, this annular surface lies in the same plane as the centres of the four screws F, which belong to the universal joint. It is therefore evident that, whatever motion be given to the weight about the universal joint, the one half of the annular surface will be turned at a corresponding angle in the direction toward C, and the other half, at the same angle, in the direction away from C. This annular movement is taken up and converted into a longitudinal one by means of the steel disc R (Fig. 2), which always presses against the flat annular surface in the ring Q. This disc R is mounted on a spindle, which is supported at the one end S on the rocking lever T, and at the other plays in a hole in a support, which extends from the base plate at U into the body of the barrel D through a hole cut in its lower side sufficiently large to admit of free play of the barrel without its coming into contact with the support. The centre of the disc and its spindle coincide with the axis of the weight and barrel when at rest.

For every movement of the weight the disc receives a motion in a line passing through the pin in the rocking lever at S, and the hole in the support within the barrel, which line is, although not quite straight, yet sufficiently so for practical purposes.

The disc R is kept pressed against the annular surface in the ring by means of the steel spring V, which is attached to and turns on the axle W, and communicates its pressure to the head of the disc spindle S, and can be adjusted by the set-screw X (Fig. 1), connected with the index and graduated arc Y, to regulate the pressure against the annular surface as desired, and in this way make the instrument more or less sensitive to oscillation.

Interposed between the head of the disc spindle S and the lower end of the spring V, is the rounded head of the lever Z, which turns the perpendicular axle a, and so communicates motion to the lever b. The lever b has a slotted hole at its extremity, in which works a screw r for attaching the lever to the connecting rod c, which gives motion to the arm d carrying a pencil e. The arm d is mounted on the perpendicular axis f, which is surrounded and moved by a spiral spring, so as to bring it back to its original position each time it has been moved by the connecting rod c. The object in having the slotted hole in the extremity of the lever b, which is attached to the connecting rod c, is to be able to adjust the arm d, so that it shall either show *all* the oscillations indicated by the weight C, *or only such parts of them as exceed a certain limit*, which limit can be assumed at pleasure.

The necessary adjustment here is effected by means of the set-screw S, the end of which presses against a stud h on the arm d, so as to move the connecting rod c towards the lever b, thus moving the screw r, which connects both connecting rod and lever, out of contact with the lever, and enabling it to traverse such distances as may be thought proper, without producing any movement in the connecting rod and the pencil. To regulate this adjustment with accuracy, there are an index q, which is fixed, and a graduated arc s, attached to the arm d.

The strip of paper i, upon which the pencil is pressed by means of the spring k, is moved in the present instance by a system of rollers and clockwork. One of these rollers l makes a complete revolution in five minutes, marking on the paper every minute by one prick, and every five minutes by two pricks of a needle point. This roller has its motion communicated to it by the clock through a spring friction arrangement, to enable the roller to be moved by hand in adjusting the paper, if necessary, without interfering with the going of the clock. The paper is delivered by the roller n, which is loose, and is rolled up by the roller m driven by a clockwork of its own. The small lever o is for putting the clock and paper in motion, and stopping them when required. The clock p gives the time of day. The paper used in this instrument is 1¼ in. wide, but otherwise similar to that used for Morse's telegraphic apparatus.

In order to make use of the instrument, it must first be decided whether it is to show all oscillations, that is, vertical and horizontal, or the vertical ones only. In the former case the instrument must be placed, as shown in Fig. 1, with the axis of the weight and barrel in the direction in which the vehicle is moving. The box containing the instrument requires merely to be placed on the floor of the carriage, etc., the oscillations of which are to be tested.

Should it be required to register the vertical oscillations only, the box must be placed so that the axis of the weight and barrel shall be at right angles to the line of the direction of the vehicle, and, to prevent any lateral oscillation which might occur to the weight, two wooden blocks, t and u (Fig. 2), are to be placed one on each side of the weight C.

FIG. 1.

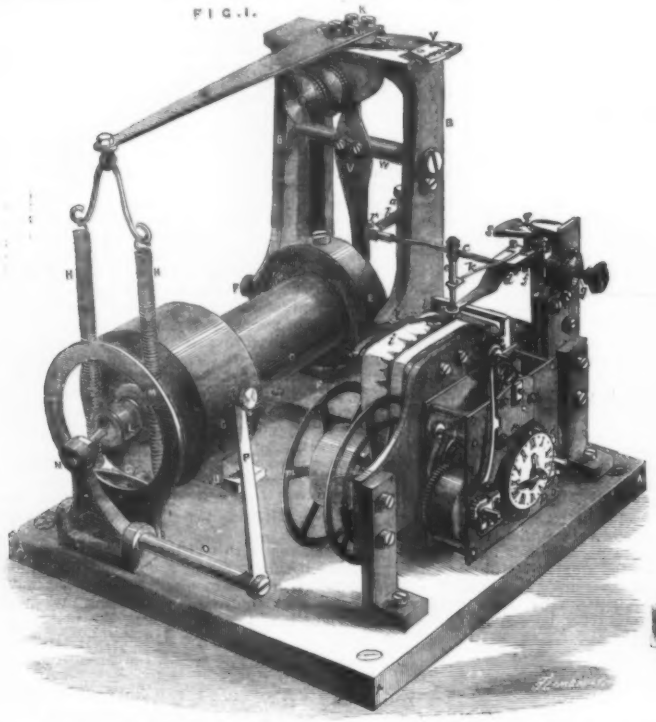
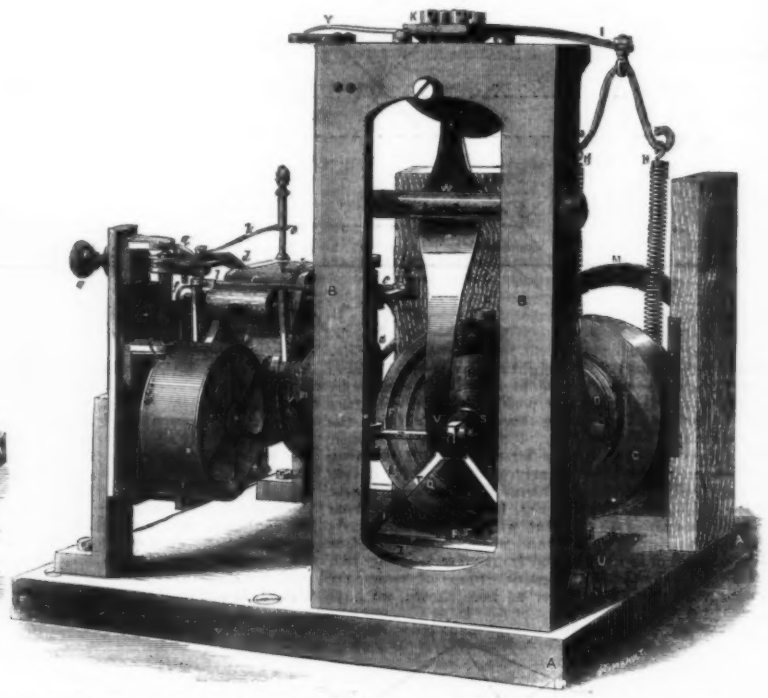


FIG. 2.



THE SEISMAGRAPH.—INSTRUMENT FOR RECORDING RAILWAY OSCILLATIONS AND SHOCKS.

These blocks allow a slight play to the weight, and are furthermore each mounted with a piece of leather to decrease any friction between them and the weight. By adjusting the set-screw *g* the slight lateral motion thus allowed to the weight will not be shown in the diagram. The degree of sensibility of the instrument required is then adjusted by the screw X.

The roller *l* and the clock *p* being set to the time of day, and the clockwork put in motion by the lever *o*, the weight C is unlocked by the lever P, and the instrument is in operation. The time the clock commences to go must be marked on a strip of paper, and, on the completion of the diagram, the time can be further marked at such intervals as may be thought proper.

We have at present before us a series of ten diagrams of the oscillations of locomotives which have been taken with the instrument just described.

The degree of sensibility of the instrument, and the limit of oscillation not recorded, are the same in all cases. The average speed of the locomotives during the journey is also mentioned on each diagram. The train taken was in every case the same, and weighed 79 tons.

Diagrams 1, 2, 3 show the oscillations of a six-wheel goods engine, run at the speeds of 20 miles, 21.95 miles, and 27.5 miles an hour respectively. This engine has wheels 4 ft. 7 in. in diameter; they are all coupled, and one pair of them is behind the firebox. The engine is of the ordinary English type of goods locomotive, with inside cylinders; it is adapted for goods trains of moderate speed, and has a wheel base of 15 ft. 5 in. These diagrams show very strikingly the effect of the increase of speed in producing oscillation. A nearer examination of them shows also that the same parts of the road have always been instrumental in producing, at the different speeds, similar lines of oscillation, though the oscillations are shown different in amount. The greatest amount of oscillation has taken place at about the middle of the time occupied by the journey, which would, under ordinary circumstances, correspond with about the half-way point between the end stations.

Diagrams 4, 5, show the oscillations of another class of goods engine, namely, a slow-speed engine of the German and Russian type. It has six wheels coupled, 4 ft. in diameter, and all the wheels are placed in front of the firebox, the wheel base measuring 11 ft. 3 in. The speeds of the engine were 13.33 miles (its normal speed), and 22.22 miles an hour respectively. A comparison between Diagram No. 2, taken at a speed of 21.95 miles per hour, and Diagram No. 5, taken at a speed of 22.22 miles per hour, shows that in this case the short-wheel-based engine from which the latter diagram was taken, had an advantage as regards steadiness, particularly at points where curves were traversed. In the absence, however, of *very* precise information as to the respective state of repair of the two engines, and concerning other points in the design beyond the mere position of the wheels, it would be impossible to deduce absolutely definite conclusions from this result.

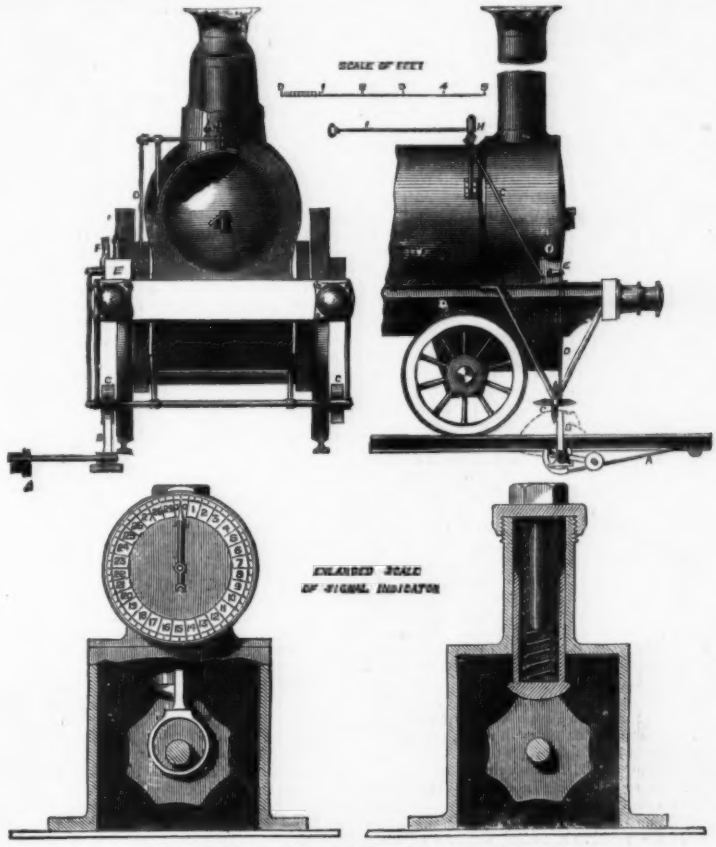
Diagram 6 is taken from an engine of a very similar type to that which afforded the last-mentioned Diagrams 4 and 5, but with this particular exception, that the height of its boiler above rail level (5 ft. 6 in.) is about 1 foot less than that of the boiler of the other engine.

The diagram shows scarcely any oscillation at all except near the middle of the journey, where there has evidently been a bad place in the road. It may be here stated that the gauge of the railway upon which these experiments were made is 5 ft. Of course it is not professed that this diagram shows *all* the oscillations made by the engine. In this, as in all the other diagrams, all small oscillations up to one and the same limit are left out, as only tending to complicate the figures.

Diagram 7 shows that, as is well known, for steady working a locomotive must be not only well designed, but kept in good order. The diagram is taken from a locomotive of exactly the same type and make as that which afforded Diagram 6, both locomotives being run at practically the same speeds, namely, the former at 13.4 and the latter at 13.33 miles an hour. In the former locomotive, however (as was also the case with all the locomotives excepting that), the diagram of which is now being dealt with, the wheels, and in fact all the parts, were in thoroughly good condition; but in this one the wheels were in bad condition, owing to defects in the tires. This locomotive was generally not in good working order, and was destined for the repairing shops.

Diagram 8 shows the oscillation of a locomotive of the mixed goods and passenger class, with outside cylinders, four coupled driving wheels, one pair of them behind the firebox (diameter of these wheels, 5 ft. 6 in.); also a pair of leading wheels 3 ft. 6 in. in diameter. The wheel base of this engine is 14 ft. The speed here was about the normal one, namely, 29.26 miles an hour, and the oscillation is, as will appear further on, chiefly *lateral*.

Diagram 9 shows the oscillation of the same engine, running at a speed of 32.4 miles an hour, and Diagram 10 those of the same engine running at 33.8 miles an hour. In this case, however, the instrument was adjusted to show *vertical* oscillations only. The Diagrams 8, 9, and 10 are uncommonly like each other as to the position of the oscillations, and might almost be taken for one and the same diagram drawn to their different scales, showing, however, that not only, as is exemplified in Diagrams 8 and 9, does speed play a most prominent part in producing oscillation in a locomotive; but, as appears from the Diagrams 8, 9, and 10, the instrument has been faithful to its record of the oscillation to which the engine was subjected, either through its own action, or the inequalities of the road.—*Engineering.*



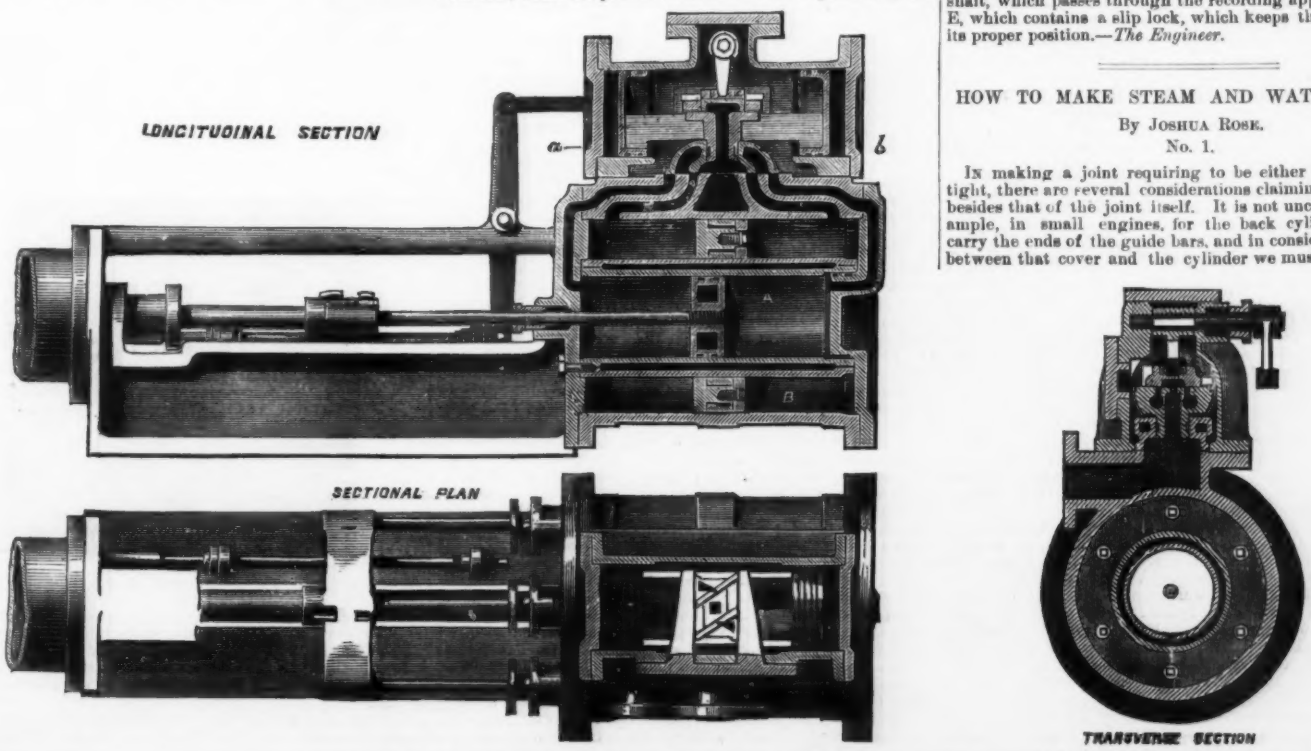
AUDIBLE RAILWAY SIGNALS.

BROWN'S AUDIBLE RAILWAY SIGNALS.

THE accompanying engravings illustrate a system of audible railway signals, the invention of T. Brown, Great Bolton, Lancashire, England. The arrangement will be readily understood from the engravings, the most important feature being the register to show the number of times which the signal has acted. F is the dial of the recorder, which is marked from 0 to 30; the finger points to the number of danger signals given, which is thus recorded on the dial, the rod G working the whistle H on the engine. The rod marked I is to stop the whistle when required. A is the wire which raises the lever B working in conjunction with the ordinary semaphore signal. C is a star wheel, coming into contact with lever B, and moving the rod D, coupled to a small lever and shaft, which passes through the recording apparatus marked E, which contains a slip lock, which keeps the star wheel in its proper position.—*The Engineer.*

DIRECT-ACTING COMPOUND STEAM PUMPING ENGINE.

FOR some years engineers have been directing their attention to the production of a simple pumping engine which will allow steam to be used expansively. As the load is constant, while the pressure varies with the expansion of the steam, and fly-wheels cannot be used under the circumstances, great difficulties stand in the way. Messrs. Tangye, London, have produced an engine in which the steam is used in two cylinders to equalize the driving force on the ram. The engine is known as Cherry's patent compound direct-acting pumping engine, and is illustrated above as manufactured by Messrs. Tangye Brothers. The arrangement is so simple that it can be explained in a few words. Steam is admitted to the interior cylinder A, and expanded thence into the exterior annular cylinder B. The simple slide valve C accomplishes the distribution of steam to each cylinder. The slide valve C is actuated by steam admitted to the small cylinders *a b* by means of a subsidiary valve *c*. The steam employed to move the slide valve is used expansively in these cylinders also, so that the least possible quantity of steam is consumed.—*The Engineer.*



NEW COMPOUND DIRECT-ACTING STEAM-ENGINE.

HOW TO MAKE STEAM AND WATER JOINTS.

By JOSHUA ROSE.

No. 1.

IN making a joint requiring to be either water or steam tight, there are several considerations claiming our attention besides that of the joint itself. It is not uncommon, for example, in small engines, for the back cylinder cover to carry the ends of the guide bars, and in considering the joint between that cover and the cylinder we must, therefore, re-

member that if the joint when made is thicker on one side than on the other, the guide bars will be thrown entirely out of line with the cylinder; and this is very likely to happen unless the cover enters the cylinder to some distance and is a driving fit. In all such cases, therefore, a ground joint should be made. The ground joint is the most perfect of any, the scraped joint not excepted; and for surfaces in which one can be moved upon the other to perform the grinding, it is a very cheap one. If the joint has occasionally to be broken, the ground joint is by far the safest and cheapest, for once properly made it will last for years, and may be taken apart and put together again as often as is necessary, with the absolute certainty that if properly cleaned and then oiled or greased, it will not leak. To make such a joint we proceed as follows: Around the bore of the cylinder, and extending nearly or quite to the bolt or stud holes, the cylinder end face should project about $\frac{1}{32}$ inch above the rest of the face, and upon the cylinder cover a similar slight projection should be left. If it should be deemed that the opening between the cylinder flange and the cylinder cover will mar the appearance, these projections may be left very slight indeed, or in cylinders up to eighteen inches in diameter may be omitted altogether. Standing the cylinder on end, with the face to be operated uppermost, we clean off the faces of the cylinder and the cover, and apply to the cover face a very light coating of red marking—that is to say, a barely perceptible coat. Red marking must not be made of red lead, because it settles to the bottom and leaves the oil floating on top. Venetian red is the best material, and it should be mixed with any lubricating oil to a thick paint, and applied to the work on a piece of rag or waste. After it is coated lightly and smoothly all over, the hand should be passed over the whole surface marked, because any grit left on the surface will cut the faces of the joint when they are rubbed together to fit them, and there is no wiping material that will so effectually clean dust from a surface as the hand will; and furthermore, the sense of touch will instantly detect any grit present. The cover may now be put into its place on the cylinder and rotated back and forth a turn or so to insure that it is properly seated, and then we may strike it a light blow with a piece of wood or the end of the handle of the chipping hammer; and if the cover does not fit pretty closely to its seat, a sharp metallic sound will be distinctly heard when the blow is struck over the parts of the face that are much out of true. Hence, by striking the blows all around the flange, we can easily find, not only the high and low spots, but can determine, after a little practice, by the degree of the sound, how much the faces are out of true. We next rub the cover back and forth on its seat, so that the marking on the cover will mark the high spots on the cylinder face. If, however, we make the forward reciprocating movement of the cover a longer one than the backward, we shall give to it a gradually rotary as well as a reciprocating movement, and this will tell us if the face of the cover is true or not, for if the marking is removed from the face of the cover in two diametrically opposite places only, it shows that the cover itself is not true; and if the cylinder face also marks on two diametrically opposite places only, it is proof that both the faces are a good deal out of true: but there is no knowing which one is the most out, and so we must file off each an equal amount. If either face marks in more than two places it is evidence that it is pretty nearly true, and it follows that that face does not need much filing. Here it becomes necessary to state why the movement of the cover, when being tried to its place, must be back and forth, as well as rotated by the movement already explained. If we revolve a radial surface of metal upon a similar surface they are extremely liable to cut or abrade each other, and the presence of the least grit will inevitably cause them to cut; and if cutting once begins, the metal gathers upon the cutting part, increasing its size so that the groove cut will get deeper until a complete revolution has been made, and this rule applies to all revolving surfaces, but more particularly to radial or conical ones.

By making the movement a partly reciprocating one we destroy this tendency, and either imbed the grit into the iron or else work it out. To proceed, however. If during our testing the blows induced a secondary and metallic sound as above described, we take a rough file and ease the high spots on both the cover and the cylinder face, filing a good deal off the face that shows diametrically opposite bearing spots only, and but very little off the face that shows three or more bearing spots. In this latter case, indeed, it is better to use a second cut than a rough file. We next wipe both faces quite clean, apply the marking to the cover as before, and try it to its seat again; rubbing it in the same manner to its seat and testing it for the metallic sound as in the first case. So soon as this sound ceases we may take a second cut file and fit the faces until they bear in at least four different places, when a smooth file should be used and the fitting and trying continued, until a very light coat of the red marking will show both the cover and the cylinder face to mark in spots not more than an inch apart; and we may then take a flat scraper, made by grinding the end and side faces, near the end, of an eight or ten inch smooth flat file to a keen edge, and with the scraper ease away the high spots, pressing the scraper firmly to its work and making it cut fine scrapings, using the scraper in strokes of about $\frac{1}{2}$ inch for a large face and $\frac{1}{4}$ inch for a small one. Where the two faces show about an even contact all over, the grinding may be performed as follows:

The two faces must be wiped quite clean, and then with an oil can we can run a line of oil around both the cylinder and cover faces, and then with the fingers sprinkle on them some dry grain emery, of a grade of about 50 for a cylinder whose diameter is, say, 14 inches or over, and of a grade of about 60 to 65 for smaller diameters; if, however, only coarser grades of emery are at hand it may be ground finer by abrasion on an iron block, using a hammer face to grind it with. The emery and oil being applied, we place the cover in its place upon the cylinder, and give to it the reciprocative rotatory movement already described, continuing the movement until the cover moves so smoothly and noiselessly that it is evident that the emery has done its duty. We then take the cover off and examine the faces.

If there are prominently bright spots upon either face, denoting that the emery has not operated upon them, it will pay to take the scraper again and ease away the dullest and most frosted-looking spots, which denote that they have suffered most during the grinding operation. The difference between the spots that have been the most and those the least affected by the grinding will be very plainly visible if the faces are wiped clean. We must continue the grinding operation with this grade of emery until the marks show the grinding to have been performed pretty evenly all over the faces, and we then apply a coating of oil and emery, as in the previous operations, the latter being in this case of a grade of about 70, moving the cover as before until it revolves so smoothly and noiselessly as to indicate that the emery is no longer doing any duty. Having continued this process, applying fresh emery and oil until the face appears true, we may perform the finishing and testing process, which is of the utmost importance, since it will detect the faintest possible defect in the job. Wiping the faces quite clean, we put the cover in place upon the cylinder again, and move it as before back and forth, and yet slowly advancing; but it must be borne in mind that if the cover makes the least jarring noise during the operation we must at once remove it and wipe it clean again, or the faces will abrade and become destroyed. There is no danger of this, however, if the cover is at once removed when the jarring sound is heard. If it is not heard, we continue the operation until the cover has made four or five revolutions and then remove it, and we shall find that the emery and oil, which had impregnated the surfaces, have worked out. We again wipe the faces clean and put them together and rub one upon the other as before, bearing in mind that if the faces cling much one to the other, we must wipe them clean again. Usually the finishing process requires performing about three times, and then the faces will have become as bright and clear as a mirror, magnifying the slightest defect in the joint. Joints made in this way will stand any pressure without leaking (unless the pressure be so great as to spring the metal of the cover), and the workman may rest assured that the joint can not leak. It is well, however, when making the joint, to put a little oil or pure tallow on the joint; and it is from this that it is called in England a grease joint, while in the United States it is termed the ground joint. It is more usual, however, in England to finish the whole joint by scraping; but this is a much more tedious job, and not so good a one, after all. Here it becomes necessary to remark, that in order to be able to handle the cover readily, it is best to bolt to it a wooden lever overhanging both sides of the cover, and to serve as a handle in moving it. And during the grinding we may place a weight on the cover, which will greatly expedite the process. It would appear that this is a long job, but such is not the case; for a 16-inch cylinder face and cover $\frac{1}{32}$ inch out of true, one with the other, can be got up in half an hour. It is obvious that this kind of joint is best suited to circular faces.

Joints for square or rectangular faces, such as steam-chests, are made in various ways. The smaller sizes are frequently made with combination rubber—that is, sheet rubber having a linen or other web running through it; with one such web it is called single, and with two webs two-ply, and so on. There is in many cases, however, an objection to this form of joint, in that it compresses; and hence in the case of the steam-chest, for example, it affects the distance of the slide-spindle hole in the chest from the seat, and throws it somewhat out of line with the eccentric. In long eccentric rods the variation is of course minute; but still it exists, and must exist, since it is impossible to tell exactly how much the rubber will compress in making the joint. Furthermore, if it is required to break such a joint, the rubber will very often cling so tenaciously to the seat in one place and to the chest in the other, that it will tear asunder in breaking the joint. To obviate this as much as possible, however, we may chalk the rubber on one face and slightly oil it on the other, so that the oil will aid the rubber in clinging to one face, while the chalk will assist it in separating from the other face, of the joint. The joints for steam-chests in American locomotive practice are made effectively and in a very cheap manner by putting in them, instead of rubber, a lining of softened sheet copper about $\frac{1}{64}$ inch thick, and in this case the seat, after planing, may be merely filed true to a straight-edge, with a second cut file.

In English railway practice, there is a very difficult joint to make upon inside cylinder locomotives, in nearly all of which the steam-chest is placed between the two cylinders, the latter being cast with one half of the steam-chest on each, and a flange being provided to bolt them together. Thus the joint runs from end to end of the cylinder, and covers a large surface, since the steam-chests are about 28 to 30 inches long and from 13 to 18 inches high. To scrape or grind up such surfaces to a steam-tight fit would be altogether too costly, and the following method is largely resorted to: the surfaces of the joint are planed and filed to fit one another tolerably accurately, and, extending to the edge of the joint and inside of the bolt holes, a V-groove is cut, so that when the cylinders are bolted together there will be formed a dovetailed groove, with the narrowest width opening into the steam-chest; into this groove a dovetailed rod of copper is slipped, extending all along the grooves, and with the narrowest part of the copper protruding into the steam-chest; with a small ball-pened riveting hammer the copper strip is then closely riveted into the groove, and thus the joint is made. In making such a joint, care must be taken not to make the groove, and hence the strip of copper, too wide, or else the copper expanding more than the cast-iron is apt to spring the joint open behind the copper.

For boiler-fittings and to stand a high temperature of steam, the best joint is the gauze-joint—that is to say, providing the fitting is not riveted to its seat, as it sometimes is; this is not, however, a commendable practice, because if the fitting should become worn out, should break, or from any other cause it required to be removed, it may be a difficult matter to get inside the boiler to rivet the new fitting. It is far better, therefore, to make a gauze-joint, which is done as follows: we first drill the holes in the flange of the fitting, which will reduce, to the extent of the area of the holes, the area of metal to be filed when fitting the joint-face; we next chip (if necessary) and then file the flange of our fitting, so that it will rest steadily upon the boiler when standing in its proper position; and when the joint is approaching a fit, we may mark through the flange the holes upon the boiler, and after drilling and tapping them, put in our studs or standing bolts, and then bolt our flange to its seat; first, however, coating the seating on the boiler with a thin coat of red marking, so that it will leave a mark upon the flange where the two faces touch. Having bolted our flange to its seat, we may cause the marking to show plainly upon the flange-seat face by striking the outside of the face with a hammer, interposing between the hammer and the flange a piece of wood, and placing the latter between the nuts; and then, when the flange is taken down, the spots where it fits to the boiler will be very plainly marked. In this connection, however, a few remarks require to be made. This method of striking the fitting to make the bedding marks show plainly must be at all times very lightly performed, especially in fitting scraped joints; for I have known many cases (especially in England) where a scraped joint has leaked from corrosion, or some similar cause, and the standing bolts or studs, being rusted in their places, could not be extracted, so that there was no alternative but to scrape up the surfaces as they stood (such a job is frequently done upon the outside ends of cylinder faces), and as a result the scraping must, on the cylinder face, be performed as the latter stands, and with the studs in. If, in such a case, we strike the outside of the cylinder cover with a hammer and piece of wood, and do not take care to do it very lightly and about evenly all over, we shall have an almost endless and assuredly a faulty job, because the force of the blow will spring the cover to the seat whether it fits in that particular spot or not, and the marks will therefore show both upon the cylinder and cover faces wherever the blows were delivered, regardless as to whether the cover bedded properly or not; and hence the scraping may be done in places where it should not be, and the marks will show all wrong, and tend to mislead. I have, from this cause, seen faces that, according to the marking, bedded well all over, leak very badly when the steam was got up, and that in English practice, in which a 16-inch cylinder cover will sometimes have 25 standing bolts around the flange; whereas in American practice not more than a dozen would be employed. In this latter case, therefore, it is better to omit striking the cover at all, unless it be done very lightly; for the marks will show plainly and properly if the marking is distributed evenly by the hand, and the cover is bolted at each trial tightly to its seat. To proceed with our boiler fitting, however: we file the flange until it fits to the conformation of the seat, but taking care that it fits the most closely around the hole—that is to say, in a ring extending from the inside of the bolt holes to the hole of the flange. And this is a highly important consideration in joints of every description, for, if a joint is made there, that is all that is necessary, and the fit outside of the bolt holes—that is to say, from the bolt holes to the perimeter of the flange—has nothing to do with making the joint, unless the studs or bolts leak, and in that case the leak will find egress beneath the nut, unless grummets are used. A grummet is a washer made of twisted hemp, cotton, or other material, and coated with red lead, or putty, as it is sometimes erroneously called, and they are placed beneath the heads of bolts, or under washers placed beneath nuts to stop leaks: they are merely, however, a convenience for rough workmanship. It is not necessary to ease the flange from the bolt holes outwards much away, but to merely make the flange or fitting bed clearly and distinctly the most around the hole and up to the inside of the bolt hole; for, if there was given too much clearance, the flange would bend from the pressure of the nuts, and would in consequence spring if made of brass, or break if made of cast-iron. We next prepare the red lead or putty as follows: Into white lead ground in oil we mix as much dry red lead as will form a mixture of the consistency of putty, making the mixture thorough by well hammering it with a hand hammer, for if this is omitted, small unmixed lumps of red lead are apt to remain and impair the quality of the mixture, and therefore of the joint. Into this mixture many will put a quantity of hemp cut into shreds about half an inch long, and then make the joint with that alone; this is defective, however, if the joint is to stand pressure. We then take some fine wire gauze—that is, gauze of wire about the $\frac{1}{24}$ of an inch in diameter, and having about 30 meshes to an inch of length—and of this we make a disc to fit the flange, taking care to cut out the gauze where there are holes in the flange. We then, with a piece of steel wire, spoon-shaped at one end, spread all over the seat of the joint a coating of the lead nearly $\frac{1}{16}$ inch thick, and place over it the gauze wire, and then bolt down our flange, and there is no fear of its leaking; if, however, the joint is an old one and in bad condition, we may make doubly sure by cutting out a second ring of gauze, making its largest diameter of sufficient size to just fit inside the standing bolts, and its inner diameter the size of the centre hole of the flange. Upon this ring we place another light coat of the red lead, and then put it in position over the first gauze, and bolt the joint up. If no mixed lead is at hand, dry lead may be used, mixing it with boiled, but not with raw, oils. Red lead will not of itself make a good joint, and is besides very difficult to spread evenly, because it will not hold together. In screwing up the nuts care should be taken to screw them up alternately and evenly, so that the flange will approach its seat equally, and not on one side before the other. The nuts should be screwed down until they all touch the flange and bring it to bear upon the lead; then give each nut successively a half turn the first time of going round, and a quarter turn the succeeding times, continuing the operation till they are tightened home. A joint of this kind may be submitted, as soon as it is made, to a steam pressure of 150 lbs. per inch, and will not leak.

DIATOMS.

THE diatoms form the last division of the *algæ* group, and occupy the same place in relation to vegetables as do the infusoria to the animal kingdom. They are microscopic algæ, formed of a single cellule called the *frustule*, which is contained in a rigid incombustible silicious envelope. The frustule is composed of two valves, between which is the so called connective band which divides the body into two parts. In the interior is the endochrome, usually of yellowish brown color, and containing a few oily drops. These organisms live in salt, in brackish, and in fresh water. While most of the

FIG. 1.—LICMOPHORA SPLENDIDA.

species belong exclusively to certain kinds of water, several may be found in water that is fresh, as well as in the sea. The marine species, which inhabit fresh water as well, are usually larger in size than the others. Sometimes they are met with in free state, and often attached to oysters or submerged stones.

The exterior of the diatom is covered with an excessively thin, gelatinous coating, which enables them to adhere together, or as parasites to other objects. It is for this reason that many of the marine confervæ and algæ, when removed from

the water and examined under a lens, appear to be covered with minute filaments or crystals.

One of the most singular characteristics of the diatom is that it always possesses a regular and even geometrical form, not only in general appearance, but in the details of the striæ, lines and points which cover the frustule. Some are exactly circular, others elliptical, and others are shaped as triangles, squares, and various rectangular figures. When massed together they

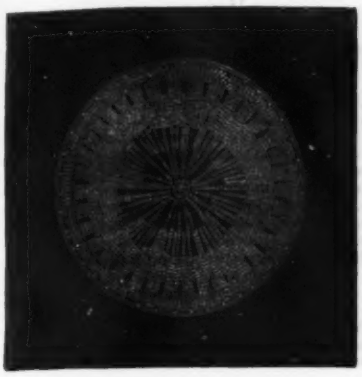


FIG. 2.—EUPODISCUS RALFSII.

usually are superposed so as to form a filament of circular or other section, according to the shape of the individual bodies. Sometimes they unite at their alternate angles and produce zigzag lines resembling a true crystallization. Again, triangular diatoms fasten themselves to stems and spread out in fan shape (Fig. 1), or form several spiral turns. The latter is due to their mode of reproduction by binary division, of which we shall speak further on.

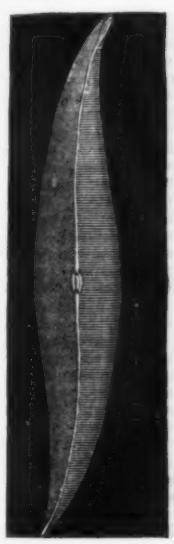


FIG. 3.—PLEUROSIGMA ANGULATUM.

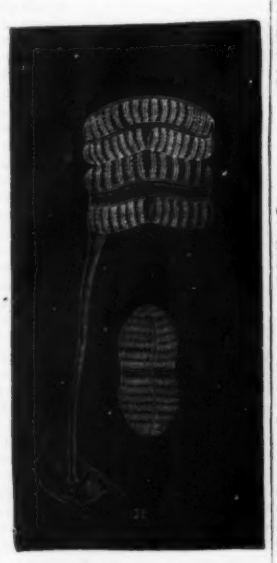


FIG. 5.—ACHNANTES LONGIPES.

The silicious matter which incrusts the shell appears to be deposited on the surface of the cellular membrane in form of excessively fine corpuscles, constituting a sort of crust. If this be dissolved by hydro-fluoric acid, the cellular membrane of vegetable nature is found beneath, having the same striæ and design as the silicious coat. It is a question among microscopists whether these striæ, dots, etc., are protuberances or depressions. It is probable that the parts are raised

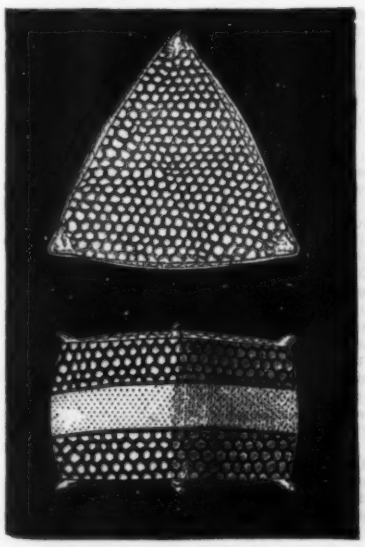


FIG. 4.—TRICERATIUM FAVUS.

or sunk according to the species. The silicious coat, however, is manifestly intended to enable the diatoms to resist the destructive action of acids and the weather; and in order to study it the bodies are boiled in nitric acid, which removes organic matter and leaves the surface perfectly clean.

This same unalterability of its shell likewise enables the diatom to resist the digestive action of the stomachs of animals. A vast number of the minute algæ are found in the intestines of aquatic insects, and even the powerful digestive apparatus of birds is incapable of dissolving them. Quantities of diatoms are met with in guano, which is simply the excrement of marine birds, and similar species are found still living in the sea-weed existing in the sea near the guano deposits.

Whole geological layers are formed of nothing but masses of the diatom envelopes. They constitute the tripolis used in polishing metals, and of this substance a bed nearly 130 feet deep has been encountered at Bilin, in Bohemia. The shells belonged to the *Navicula* species. A fresh-water variety of the same species produced the deposit at Planitz, in Saxony. The determination of the species of fossil diatoms allows of the accurate recognition of alluvions, and this is not difficult, as the majority of the species still exist alive.

In this manner, says M. Jules Gerard, evident proof is afforded of the sojourn of water in deposits now covered thickly with earth. The city of Berlin rests on a clayey peat, from 21.4 to 60 feet thick, composed of diatom fragments. At Wismar (Mecklenburg-Schwerin) the adjacent water deposits some 18,000 cubic feet of diatoms annually. Richmond, Va., is built on a diatom bed 18 feet thick. The distribution of the organisms is world-wide—new varieties are constantly being found. In the Island of Mull (Scotland) the dry bottom of Lake Boa, belonging to the jurassic period furnished Professor Gregory with 130 new species.

Tripoli produced by diatoms is often adulterated with sand, in commerce—a fact easily detected by the microscope. M. de Brebisson has recently prepared an artificial tripoli by the incineration of the filamentous diatom known as *Hemantidium pectinale*, an abundant species of a greenish brown color. He has employed the material with excellent results for polishing daguerreotype plates.

The annexed engravings, taken from *La Nature*, represent highly magnified various diatom species. Fig. 1, already described, is the *Licmophora splendida;* Fig. 2 is the *Eupodiscus Ralfsii*, resembling the section of a branch of a tree. Fig. 3 is the *Pleurosigma angulatum;* a favorite test object for microscopes. The right-hand side of the figure shows the system of transverse striæ, such as are defined by a low-power objective, the light being directed parallel to the long axis of the frustule. On the left is shown the two systems of oblique striæ obtained by the same objective with the light directed parallel to the minor axis. A diagonal light shows the three systems at once, and determines a hexagonal reticulation. Fig. 4 is the *Triceratium favus*, face and profile. Fig. 5 is the *Achnantes longipes*, attached in clusters to a stem. The diatom itself is shown singly below.

PROF. HUXLEY IN AMERICA.

THE THEORY OF EVOLUTION.

THE first of Prof. Huxley's series of lectures on the "Theory of Evolution," was given in Chickering Hall, New York, on the 18th of September, before a large audience. Prof. Huxley's method is slow, says the *New York Times*, precise, and clear, and he guards the positions which he takes with astuteness and ability. He does not utter any thing in the reckless fashion which conviction sometimes countenances and excuses, but rather with the deliberation which research and close inquiry foster. He is seemingly very modest in declining to meddle with matters outside of his sphere, but he has a Ciceronian way of saying that he will not denounce such and such an hypothesis, when the very negation implies that it ought, in his opinion, to be denounced. Under the aspect of calm judicial solemnity Prof. Huxley is a brilliant advocate.

THE LECTURE.

LADIES AND GENTLEMEN: We live and form a part of a system of immense diversity, which we call nature, and it is a matter of the deepest interest to all of us that we should form a just conception of the constitution of that system and of its past history. In relation to this universe, man is in this state little more than a mathematical point in duration—but a fleeting shadow. He is a reed shaken in the wind of forms; although a reed, he is a thinking reed, and in virtue of that wonderful capacity of thought, he has the power of framing to himself a symbolical section of the universe, which, although doubtless highly imperfect, and although wholly inadequate as a picture of that great future, yet is sufficiently accurate to serve him as a guide-book and a map in his practical affairs. It has taken long ages and accumulations of great labor to enable man to look steadily at the varied phantasmagoria of nature to discern what is stable amid her fluctuations, and what is regular among her forces. It is only comparatively lately—within the last two centuries—that has emerged the conception of a pervading order and a definite cause of things, which we term the course of nature. But out of this contemplation of nature, and out of man's thought concerning her, there has in these later times arisen that conception of the consistency of nature to which I have referred, and at length that has become a guiding conception of modern thought. It has ceased to be almost conceivable to any person who has paid attention to modern thought that chance should have any place in the universe, or that events should follow in but the natural order of cause and effect. We have come to look upon the present as the child of the past and as the parent of the future, and as we have excluded chance from any share or part in the order of things, so in the present order of nature men have come to neglect even as a possibility the notion of any interference with that order. And whatever may be men's personal notions upon these subjects, it is quite certain that every intelligent person guides his lights and risks his fortune upon the belief that the order of nature is constant and the relation of cause and effect unchangeable. In fact, there is no belief which we entertain which has so complete and logical a basis as that to which I have just referred. It underlies tacitly every process of reason; it is the foundation of every act of the will; it is based upon the broadest induction; it is verified by the most constant and regular and universal of the deductive processes. But we must recollect that any human belief, however broad its basis, however dependable it may seem, is, after all, only a probable belief, and that our broadest generalizations are simply the highest degree of probability; and although we might be quite clear about the consistency of nature at the present time and in the present order of things, it by no means follows necessarily that we are justified in extending that generalization into the past; and denying absolutely that there may have been a time when events did not follow a constant order, when relations of cause and effect were not fixed and definite, and when external agencies did not intervene in the general course of nature, the cautious man will admit that such a change in the order of nature may have been passed, just as a very candid thinker will admit that there may be a world in which two and two do not make four, and in which two straight lines do not inclose a space. In fact, this question with which I have to deal in the three lectures which I shall have the honor to deliver before you—this question as to the past order of nature—is essentially a historical question, and it is one that must be dealt with in the same way that any difficult problem is dealt with.

VIEWS REGARDING THE ORDER OF NATURE IN THE PAST.

I will, in the first place, state to you what are the views which have been entertained respecting the order of nature in the past, and then I will consider what evidence is in our possession bearing upon the question, and by what the evidence is to be interpreted. So far as I know, there are only three views—three hypotheses—which have ever been entertained, or which well can be entertained, respecting the past history of nature. Upon the first of these the assumption is that the order of nature which now obtains has always obtained—in other words, that the present course of nature, the present order of things, has subsisted from all eternity. The second hypothesis is, that the present state of things, the present order of nature, has had only a little duration, and that at some period in the past the state of things which we now know substantially, though not of course in all details, but the state of things which we now know, arose and came into existence without any precedent similar condition from which it proceeded. The third hypothesis also assumes that the present order of nature has had but a limited duration, but it supposes that the present order of things proceeds by natural process from an antecedent order, and that from another antecedent order, and so on. And on this hypothesis the attempt to fix any limit at which we can assign the commencement of this series of changes is given up. I am very anxious that you should realize what these three hypotheses mean; that is to say, what they involve. If you can, imagine a spectator to have been present during the period to which they refer. On the first hypothesis, however far back in time you place that spectator, he would have seen a world essentially, though not perhaps in all its details, similar to that which now exists. The animals which exist would be the ancestors of those which now exist, and like them. The plants in like manner would be such as we now have, and like them. And the supposition is, that at however distant a period in time you place your observer, he would still find mountains and dry land, and seas and rivers, and animal and vegetable products flourishing upon them or sporting in them, just as he finds now. That view has been held. It was a favorite fancy of antiquity, and has survived along down toward the present day, and it is worthy of remark that it is a hypothesis which is not inconsistent with what geologists are familiar, and the doctrine held by Hutton and in his earlier days by Lyell; for Hutton, struck with a demonstration of astronomers, that the perturbations of the planetary bodies, however great they may be, yet sooner or later righted themselves, and that the solar system thus contained within itself, so to speak, a self-adjusting power, by which these aberrations were cured, and itself brought back to a state of equilibrium—Hutton imagined that something of the same kind may go on in the earth, and although no one recognized more clearly than he the fact that the dry land is being constantly washed down by rain and rivers and deposited in the sea, and that thus, in a certain length of time, greater or shorter, the inequalities of its surface must be levelled and its high lands be brought down to the sea bottom; yet take into account the internal force of nature by which the upheavals of deep seas leave us new land, and it is no unnatural imagining that these two processes compensate one another, and that thus substantially, if not in assignable time, the general features of the earth might remain what they are. And inasmuch as they are not confined by any limit under this circumstance to the successive development of the duration of animals and plants, it is clear that the logical development of this idea might lead to the conception of the eternity of the world—not that I mean to say or suggest that either Hutton or Lyell held this suspicion—assuredly not. They would have been the first to repudiate it. But it remains nevertheless true that by the arguments which they use it might have been possible to justify this hypothesis.

THE HYPOTHESIS OF SUDDEN ORIGIN.

The second hypothesis, that to which I have referred as the hypothesis which supposes that this order of things had at some no very remote period of time a sudden origin, such as it now is, that is the doctrine which you will find stated most fully and clearly in the immortal poem of John Milton, the English *Divina Commedia*, "Paradise Lost." I believe it is largely through the influence of that remarkable work, combined with daily teachings to which we have all listened in our childhood, that this hypothesis owes its general wide diffusion as one of the current beliefs of English-speaking people. If you turn to the seventh book of "Paradise Lost" you will find there stated the hypothesis to which I refer, and which is this, that this visible universe of ours made its appearance at no great distance of time from the present day, and that the parts of which it is composed made their appearance in a certain definite order in the space of six natural days, and in such a manner that in the first of these days light appeared; that in the second the firmament or sky separated the water above it from the water beneath it; that on the third day the waters drew away from the dry land, and all the forms of vegetable life which now exist made their appearance; that the fourth day was devoted to the apparition of the sun and the stars, the moon and the planets; that on the fifth day aquatic animals originated in the waters; that on the sixth day the earth gave rise to her terrestrial creatures and to all varieties of terrestrial animals except birds, which had appeared on the preceding day, while finally man appeared upon the earth, and the work of fashioning the universe was finished. John Milton, as I have said, leaves no doubt whatever as to how, in his judgment, this marvellous process occurred. I doubt not that his immortal poem is familiar to all of you; but I should like to recall one passage to your minds, in order that I may be justified in what I shall have to say, and what I have said regarding the perfectly concrete and definite conception which Milton had of what he thought had been the mode of origin of the animal world. He says:

> The sixth, and of creation last, arose
> With evening harp and matin; when God said,
> Let the earth bring forth soul living in her kind,
> Cattle and creeping things and beast of the earth,
> Each in their kind. The earth obey'd and straight
> Opening her fertile womb teem'd at a birth
> Innumerous living creatures, perfect forms,
> Limb'd and full-grown; out of the ground uprose,
> As from his lair, the wild beast, where he roams
> In forest wild, in thicket, brake or den;
> Among the trees in pairs they rose, they walked;
> The cattle in the fields and meadows green,
> Those rare and solitary, those in flocks
> Pasturing at once, and in broad herds upsprung.
>
> The grassy clods now calv'd; now half appear'd
> The tawny lion, pawning to get free
> His hinder parts, then springs, as broke from bonds
> And rampant shakes his brinded mane;
> The libbard, and the tiger, as the mole, the ounce,

Rising, the crumbled earth above them threw
In hillocks; the swift stag from underground
Bore up his branching head; scarce from his mould
Behemoth, biggest born of earth, upheav'd
His vastness; fleec'd the flocks, and bleating rose,
As plants; ambiguous between sea and land
The river horse, and scaly crocodile.
At once came forth whatever creeps the ground.

There is no doubt as to the meaning of that hypothesis, or as to what a man of Milton's genius expected would have been actually visible to one who could have witnessed the process of origination of living things as he describes them.

THE HYPOTHESIS OF EVOLUTION.

And then comes the third hypothesis, which is the hypothesis of evolution. That supposes that at any given period in the past we should meet with a state of things more or less similar to the present, but less similar in proportion as we go back in time; that the physical frame of the earth could be traced back in this way to a condition in which its parts were separated into little more than a nebulous cloud, making part of the commoner substance into which we should find the sun and the other planetary bodies also resolved; and that if we trace back the animal world, or vegetable world, we should find preceding the present fauna and flora, animals and plants—not identical with them, but like them—only increasing their differences as you go back in time, and, at the same time, becoming simpler and simpler until eventually we should arrive at that gelatinous mass which, so far as our present knowledge goes, is the common foundation of all life, and whether we could trace that further or not, is uncertain; but, at any rate, the force of science tends to justify the speculation that that also could be traced into some thing common in itself, and the general nebulous foundation of universal matter. The hypothesis of evolution supposes that in all this past progression there would be no breach of continuity, no point at which you could say this is a natural process, and that is not a natural process; but that the whole might be strictly compared to that wonderful series of changes which may be seen going on every day under our eyes, in virtue of which there arises out of that semi-fluid homogeneous substance which we call an egg, the delicate organization of one of the higher animals. That, in a few words, is what is meant by the hypothesis of evolution.

HOW THE UNIVERSE CAME INTO EXISTENCE.

I have already suggested that in dealing with these three hypotheses, in endeavoring to form a judgment as to which of them is the most worthy of belief, or whether none is worthy of belief, our condition of mind should be that of suspension of judgment, which is so difficult to all but trained minds. I have suggested that in dealing with this question we should get rid of all *a priori* considerations. The question is a question of fact, of historical fact. The universe has come into existence somehow or other, and the question is whether it came into existence in one fashion or whether it came into existence in another fashion. And as an essential preliminary to this consideration, permit me to say two or three words as to the nature of historical evidence, and the kinds of historical evidence. Evidence as to the occurrence of any fact in past time is of one of two kinds, which for convenience sake I will speak of, on the one hand as testimonial evidence, and on the other hand as circumstantial evidence. By testimonial evidence I mean human testimony, either direct or indirect; and by circumstantial evidence I mean evidence which is not human testimony. Let me illustrate by a familiar case what I mean by these two kinds of evidence, and what is to be said respecting their value. Suppose that a man tells you that he saw a person strike another and kill him. That is testimonial evidence of the fact of murder. But it is possible to have circumstantial evidence of the fact of murder—that is to say, you may find a man dying, with a wound upon his head having exactly the form and character of a wound which is made by an axe; and, with due precaution, you may conclude with the utmost certainty that the man has been murdered, and is dying in consequence of the violence inflicted by that implement. We are very much in the habit of considering circumstantial evidence as of less value than testimonial evidence. And it may be in many cases where the circumstances are not perfectly clear and perfectly intelligible that it is a dangerous and uncertain kind of evidence. But it must not be forgotten that in many cases it is quite as good as testimonial evidence, and that in many cases it is a great deal better than testimonial evidence. For example, take the case to which I referred just now. The circumstantial evidence is better and more convincing than the testimonial evidence. For it is impossible, under the circumstances that I have mentioned, to suppose that the man had met his death from any cause but the violent blow of the axe, and circumstantial evidence of murder having been done in that case is as complete and as convincing as evidence can be; it is evidence which is open to no doubt and no falsification. But the testimony of a witness is open to multitudinous errors: he may have been actuated by malice; and it is possible, and constantly has happened, that even a number of persons have declared that a thing has happened in this or that or the other way, when a careful analysis of the circumstantial evidence has shown that it did not happen in that way, but in some other, which cases are clear ones of the value of circumstantial evidence, and of the fact that it may be evidence of the highest weight and of the highest authority.

THE ETERNITY OF THE WORLD'S DURATION.

Now, let us turn to our third hypothesis, and let me first direct your attention to what is to be said about the hypothesis of the eternity of this state of things in which we now are. What would first strike you is, that that is a hypothesis which, whether true or false, is not capable of verification by evidence. For, in order to testify to the eternity of duration, you must have an eternity of witnesses or an infinity of circumstances, and neither of these is attainable. It is utterly impossible that such evidence should be carried beyond a certain point of time, and all that would be said, at most, would be that there was nothing to contradict the hypothesis. When you look into the testimonial evidence it might not be good for much in this case. But when you look into the circumstantial evidence, then you find that this hypothesis is absolutely incompatible with that circumstantial evidence. And the evidence is of so plain and so simple a character, that it is impossible in any way to escape from the conclusion which it forces upon us. You are, in fact, already aware that the crust of the earth, the superficial part of the earth, is not of a homogeneous character, but it is made up of a number of beds or strata, the titles of the principal groups of which are placed upon that diagram—beds of sand, beds of stone, beds of clay, of slate, of granite, and various other material. On careful examination it is found that these beds of solid material are of exactly the same nature as those which are at present being formed under new conditions at the surface of the earth; that the chalk, for example, which forms a great part of the cretaceous formation in some parts of the world—that that chalk is identical in its physical characters, or practically so, with the substance which is now being formed at the bottom of the Atlantic Ocean, and covers an enormous area; that the beds of rock are exactly comparable to the sands which are being formed upon the sea shores and hardened and compacted together; that others are of exactly the same nature as the clays, and so on. And thus it comes to be certain that each of these beds of rock, of which a total of not less than some seventy thousand feet is known—that all these have been deposited and formed by natural agencies either out of the waste and washing of the dry land, or else as the product of the energies of animals, and, it may be, of plants. Hence, these superimposed beds which constitute the crust of the earth, become a measure of time—not a measure of absolute time, for we have, as yet, not succeeded in saying certainly how much time is required to form a bed of any given thickness; but they become a measure of relative time, and inasmuch as it follows from the manner in which those beds have been formed that the uppermost must needs be the youngest, the undermost must be the oldest, and we have before us evidence of the succession of the events which they recall. And now these rocks or strata are full of the remains of animals and plants, countless thousands of different species of animals and plants, as perfectly recognizable as those which you meet with in herbarii at the present day, or the shells or remains which you pick up on the beach. Countless thousands of these creatures have been imbedded in the sand or in the limestone, just as they are being imbedded now, and consequently they furnish us with a record, which can not be subject to any interpretations, looking at them broadly, of the kind of things which have lived on the surface of the earth during the time which is embraced by this great system of stratified rocks, and the most superficial study of the remains shows us that the animals and plants which live at the present time have had only a temporary duration; that you find them, and such as they are, for the most part only in this uppermost stratum here [pointing on blackboard], called the post tertiary; that as you go back in time they become scantier and scantier, but their places are taken by other forms as diversified as they, but still different; that as you go into the jurassic and triassic strata, there you find others, different from the cretaceous and different from the tertiary, and different from those of the present day, and so as you go deeper and deeper and further and further back into time. Here, then, the circumstantial evidence absolutely antagonizes the evidence of the eternity of the present condition of things. We can see with certainty that such has not always been the mode of nature. We can see with certainty that the present condition of things has been of comparatively short duration, and that so far as the animal and vegetable worlds are concerned they have been preceded by a different condition of things; that we can go on till we come to the lowest or unstratified rocks, in which we lose the indications of life altogether. The hypothesis of the eternity of the present condition of things may therefore be put out of court altogether.

THE MILTONIC HYPOTHESIS.

We now come to what I have called Milton's hypothesis—the hypothesis that the present condition of things has endured for a comparatively moderate time, and then at the commencement of that time came into existence, within the course of six days. I doubt not that it may have excited some surprise in your minds that I should have spoken of this as John Milton's hypothesis rather than that I should have used terms which are much more familiar to you, such as the doctrine of creation, or the Biblical doctrine, or the doctrine of Moses, all of which terms as applied to the hypothesis to which I have just referred are certainly much more familiar to you than the title of the Miltonic hypothesis. But I have what I cannot but think a very weighty reason for taking the course which I have pursued. For example, I have discarded the title of the hypothesis of creation, because my present business is not with the question as to how nature has originated or to the causes which have led to her origination, but as to the manner and order of her origination. Our present inquiry is not why the objects which constitute nature came into existence, but when they came into existence, and in what order. That is a strictly historical question—a question as plainly historical as that about the date at which the Angles and Jutes invaded England. But the other question, the question about creation, is a philosophical question, and one which cannot be solved or approached or touched by the historical method. What we want to know is, whether there is evidence in the facts so far as they are known, that things arose in the way they are described by John Milton, or whether they did not. When that question is settled it will be quite time enough to proceed to the further inquiry as to the manner in which it arose. And in the second place I have not spoken of it as the Biblical hypothesis. It is quite true that persons are discrepant in their general views, as Milton, the Protestant, and Father Schwari, the Jesuit, agree in their interpretation of the first chapter of Genesis—the interpretation which Milton has adopted. It is quite true that that interpretation, unless I mistake, is that which has been instilled into every one of us in our childhood; but I don't for one moment venture to say that it can properly be called the Biblical doctrine. In the first place that is not my business. It is not my business to say what the Hebrew text contains, and what it does not; and in the second place, were I to say that this is the Biblical hypothesis, I should be met by the authority of many an eminent scholar, to say nothing of men of science, who in recent times have absolutely denied that this doctrine is to be found in Genesis at all. If we are to listen to them, we must believe that what seems so clearly spoken of as days of creation that we could make no mistake on that subject are not days at all, but periods of time, which you may make just as long as convenience may require. And again, if we are to listen to them, we are to believe that when the verse says that God made the beasts of the field, it is perfectly consistent with the phraseology to believe that they may have been evolved by natural processes lasting for millions of years. A person who is not a critic and is not a Hebrew scholar can only stand up and admire the marvellous flexibility of the language which admits of such diverse interpretations. [Laughter and applause.] Assuredly in the face of such contradictory authority upon matters upon which he is competent to form no judgment he will abstain from giving any opinion—as I do. [Applause.] And in the third place, I have carefully abstained from speaking of this view as the Mosaic doctrine, because we are now assured, upon the authority of the highest critics, and even of dignitaries of the Church, that there is no evidence whatever that Moses wrote this particular chapter or knew any thing about it. I don't say. I give no opinion. It would be impertinent upon my part to volunteer an opinion upon such a subject. But that being the state of opinion among scholars, persons who have devoted their lives to this subject, and who must be listened to, I think it is well that we, the laity, who stand outside, should be careful to avoid entangling ourselves in such a vexed question. [Applause.] So, as Milton leaves us in no sort of doubt, as, happily, Milton leaves us in no ambiguity as to what he means, I will still continue to speak of it as the Miltonic hypothesis. [Applause.]

TESTING THE MILTONIC VIEW.

Now, then, we have to test that hypothesis. For my part I have no prejudice one way or the other. If there is evidence in favor of this view, I, for one, have no sort of theoretical difficulties in the way of accepting it. But there must be evidence. We men of science get an awkward habit—no, I won't call it that, for it is a most valuable habit—of refusing to say that we believe any thing unless there is evidence for it; and we have a way of looking upon belief which is not based upon evidence not only as illogical, but as immoral. [Applause.] But now we will, if you please, test this view carefully in the light of facts. From what I have said you will understand that I don't propose to discuss the question of what testimonial evidence is to be adduced in favor of this view. If those whose business it is to judge are not at one as to the authenticity of the document, or the fact to which it bears witness, the discussion of the testimonial evidence is superfluous. But one regrets this the less, because the circumstantial evidence, if carefully considered, leads me to the conclusion that it is out of court altogether, and can not be adduced. And the considerations upon which I base that conviction are of the simplest possible character. Whatever the flexibility of the interpretation of Milton's view, it is quite impossible to deny that the kernel of the whole matter is a statement as to an order of succession of living forms. It is stated that plants, for example, made their appearance upon the third day, and not the fourth. And you will understand, it is perfectly obvious, if considered, that what must be meant by plants are the plants which now live, the trees and shrubbery which we now have. For, if not, one of two things—either the existing plants have been the result of separate origination, of which we have no record, and for the supposition of which there is no justification—or else they have arisen by that dreaded process of evolution from the original stock. And, in the second place, it is clear that there was no animal life before the fourth day, and that on the fourth day marine animals and birds appeared. And it is further clear that terrestrial life and creeping things are especially mentioned—that terrestrial life made its appearance on the sixth day, and not before. Whence it follows that if in this record, in this huge mass of circumstantial evidence as to what really has happened in the past history of the globe, if in that we find, down to a certain point, indications of the existence of terrestrial animals, it is perfectly certain that all that has taken place since the time at which we find those remains of terrestrial animals must be referred to the sixth day. Now, what is in fact the case? In this great carboniferous formation from whence America derives so vast a proportion of her actual and potential wealth, in that carboniferous formation, and in the beds of coal which are formed of the vegetation of that period, we find abundant evidence of the existence of terrestrial animals. They have been described not only by European naturalists, but also by your own naturalists. They are to be found in the coal of your own coal fields. Numerous insects, allied to our cockroaches, for example, are to be found there; scorpions of large size, and so similar to existing scorpions that it requires the practised eye of the naturalist to distinguish them; and even spiders. Inasmuch as these things can be proved to have had full life and activity in the carboniferous epoch, it is perfectly clear that if the Miltonic account is correct all this deposit, all this huge mass of rock, extending from the middle of the palæozoic forms up to the present time, all that must belong to the time, or period, or whatever you like to call it, which is termed by Milton the sixth day of the Creation.

THE ORDER IN WHICH ANIMALS WERE CREATED.

But further, it is expressly stated that aquatic animals took their origin upon the fifth day, and did not exist before; hence all formations in which aquatic animals could be proved to exist, and which, therefore, lived at the time at which these formations were deposited, must have been deposited during or since the period which Milton speaks of as the fifth day; but there is absolutely no fossiliferous rock in which you do not find the remains of marine animals. The earliest forms of life in the lower Silurian are marine animals, belonging to brutes which exist at the present day, and if the view which is entertained by Principal Dawson and by Dr. Carpenter, of the animal life of the eocene, be correct, then it is true that animal remains exist at a period, as indicated by the thickness of the deposit, as far antecedent to the deposit of coal as coal is from us, at the very bottom of the stratified rock, in what are called the Laurentian strata. It follows plainly enough from this that the whole series of stratified rock, if they are to be brought into harmony with the Miltonic account at all, must be referred to the fifth and the sixth days, and that we absolutely can not hope to find the slightest trace of the work of the other days in our stratified formations. When one comes to consider this one sees at once how absolutely futile are all the attempts that have been made to run a parallel between the stratified rocks as we know them, and the account which Milton gives us. If the whole series of stratified rock must needs be referred to the two last periods, it is of course futile to look upon the animals of which we have any trace as corresponding with those which were introduced upon the earth, according to the hypothesis, upon the sixth day. But not only is there this objection to any attempt to run a parallel between the Miltonic account and the actual fact, but there is this further difficulty: In the Miltonic account it is stated not only that marine animals made their appearance upon the fifth day, but among those marine animals are mentioned all varieties of fish, and the great whales, and birds, the fowl of the air. If that be so, and if there be any correspondence between the record of the rock and the Miltonic account, the order in which animals should have made their appearance in the stratified rock should be this: Fishes, including the great whales and birds; after that, all varieties of terrestrial animals. Nothing can be further from the facts as we find them. As a matter of fact we know of not the slightest evidence of the existence of birds before what are there indicated [referring to the chart] as the jurassic, and perhaps (for it is doubtful) the triassic formation. If there were any parallels between the Miltonic account and the circumstantial evidence, they ought to be found in the Silurian rock and in the carboniferous. This is not the case, and not a trace of birds makes its appearance until the far later period which I have mentioned. But, again, if it be true that all varieties of fishes, and the great whales and the like, made their appearance on the fifth day, then we ought to find the remains of these

things in the older rock, in those which preceded the carboniferous epoch. Fishes, it is true, we find, and numerous fishes, but the great whales are absent, and the fishes are not such as now live; not one solitary species of fish which is now in existence is to be found there, and hence you are introduced again to the difficulty and the dilemma that the creatures which were created then, which came into existence on the sixth day, were not those which are found at present; are not the direct and immediate ancestors of those which now exist; and in that case you must either attach a fresh origin, of which nothing can be said, or you must have evolution, or else the whole story must be given up as absolutely devoid of any circumstantial evidence; and it is to that latter conclusion, ladies and gentlemen, that we are irresistibly driven.

THE CIRCUMSTANTIAL EVIDENCE.

I have put before you in a few words, some little time ago, a statement of the sum and substance of Milton's hypothesis. Let me try now to put before you in a few words the sum and substance of the circumstantial evidence as to the past history of the earth, which is written without the possibility of mistake, with no chance of error in the stratified rock. What we find is that that great series of formations represents a period of time of which our human chronology hardly affords us a unit of measure. I will not pretend to say how we ought to measure this time—in millions or in billions. Luckily for me, and, perhaps for my argument, that is wholly unessential; but that the time was enormous—was vast—there is no sort of question. We find written upon this record, and as resulting from the simplest methods of interpretation, the conviction that all that is now dry land has once been at the bottom of the waters—if we leave out of view certain patches of metamorphosed rock, certain volcanic products. It is perfectly certain that at a comparatively recent period of the world's history—at that epoch the name of which is written on this chart as the cretaceous epoch—no one of the great physical features which at present mark the present surface of the globe existed. It is certain that the Rocky Mountains were not; it is certain that the Himalaya Mountains were not; it is certain that the Alps and the Pyrenees had no existence. The evidence is of the simplest possible character—simply this, that you find raised up upon the flanks of these mountains, elevated by the forces of upheaval which have given rise to them, masses of cretaceous rock which formed the bottom of the sea before those mountains existed. It is, therefore, perfectly clear that the elementary forces which gave rise to the mountains are subsequent to the cretaceous epoch; that the mountains themselves are largely made up of the materials deposited in the sea which once occupied their place. We meet, as we go back in time, with constant alternations of sea and land, of estuary and open ocean, and corresponding with these alternations we meet with changes in the flora and fauna. But no close inspection of these changes gives us the slightest right to believe that there has been any discontinuity in natural processes. There is no trace of a sweeping deluge or sudden disturbance of organic life. As our knowledge increases, the blanks between the different formations have been filled up. It can now be shown that there is no absolute break between formation and formation; that there has been no sudden disappearance of all the forms of life at one time and displacement by others, but that every thing has gone on slowly and gradually; that one fauna has died out, that another has taken its place, and that thus, by slow degrees, one fauna has been replaced by another. So that, within the whole of the immense period indicated by these stratified rocks, there is a surety—leaving evolution out of the question altogether—there is a surety of not the slightest trace of any break of the uniformity of nature's operations, not a shadow of indication that events have followed other than their natural and orderly course. That, I say, is the plainest and the most obvious teaching of the circumstantial evidence which is contained in the stratified rocks. I leave it to you to consider how far, by any ingenuity of interpretation, by any stretching of the meaning of language, it can be brought into the smallest similarity with that view which I have put before you as the Miltonic doctrine.

THE EVIDENCES OF EVOLUTION.

There remains the third hypothesis, which I have spoken of as the hypothesis of evolution, and I propose that, in the lectures to come, we should consider that as carefully as we have considered the other two hypotheses. It is quite hopeless to look for testimonial evidence of evolution. The very nature of the case precludes the possibility of such evidence. Our important inquiry is what foundation the circumstantial evidence lends to the hypothesis, or whether it lends any, or whether it controverts it, and I should deal with the matter entirely as a question of history. I should not indulge in the discussion of any speculative probability. I should not attempt to show that nature is unintelligible unless we adopt some such hypothesis, which, for any thing that I know to the contrary, may be true, that it is the business of nature to be unintelligible. She is often very puzzling, and I have no right to suppose that she is bound to fit herself to our notions of impenetrability; but I should deal with the matter entirely from the point of view of history, and I should place before you three kinds of evidence, entirely based upon what we know of the forms of animal life which are contained in the series of stratified rock. I should endeavor to show you that there is one kind of evidence which is neutral, which neither helps evolution nor is inconsistent with it. I should then endeavor to show you that there is a second kind of evidence which gives a strong probability in favor of evolution, but does not prove it. And lastly, I should endeavor to show that there is a third kind of evidence, which, being as complete as any evidence which we can hope to obtain upon such a subject, and, being wholly and entirely in favor of evolution, may be fairly called demonstrative evidence of its having occurred. But these matters, ladies and gentlemen, I propose to deal with in the course of the next two lectures. [Loud applause.]

THE COURSE OF CERTAIN BRAIN FIBRES.

A. FREY communicates the following case to the *Arch. f. Psych., etc.*, vi. p. 327. A man died of erysipelas soon after the development of the symptoms of a localized cerebral paresis. At the autopsy the only lesion found was a small, sharply circumscribed focus of softening in the middle of the white substance of the right hemisphere, at the level of the under surface of the corpus callosum, between the nucleus caudatus internally, and the fossa of Sylvius externally, at about the height of the anterior third of the corpus striatum. As the paresis involved the whole left arm, left angle of the mouth, and left half of the tongue, it was assumed that the fibres for the innervation of these parts must run through the seat of softening.—*Centralbl. f. d. Med. Wiss.*

HEALTH OF DENTISTS.

AT the recent sixteenth annual session of the American Dental Association, Philadelphia, the special committee on the subject relating to the health of the dentist was called upon, and the chairman, Dr. Allen, made a report:

Dr. Allen's paper said that a heavy dental practice tends to overtax the system more severely than other callings; the reasons assigned being the close confinement, and more especially the numerous intricate operations he is required to perform under trying circumstances, and a neglect to obey established laws. These are often neglected more from indifference than from want of knowledge, but a plea of ignorance will not avail. As we can not change the nature of our calling, we should make our habits accord with the laws of health. The paper then contrasted the practice of medicine with that of dentistry, as regards their effect upon the health of the practitioner. The variation in the employments of the former, his out-of-door exercise in going from patient to patient, were considered far less taxing than the difficult operations of the dentist, which cause a prolonged tension upon the brain without the recuperative effect of the open air. This, repeated, is liable to result in pathological conditions of cerebral anæmia, and if long continued, in dementia, particularly when the tension is of a chafing character. It is not brain-work, but brain-excitement, that eventuates in disease. The bad ventilation of dental rooms subjects the operator to the ill effects of vitiated air. One and a half hogsheads of pure air are required for the respiration of each person every hour, and if it is denied, the result is death, as has been shown by the historical instance in which one hundred and twenty-three men out of one hundred and forty-six perished in a single night from this cause.

The use of narcotics and stimulants was then adverted to. Their use was condemned as not required for the building up of the tissues, though when required they may serve a temporary purpose. They should be especially shunned by overworked dentists, who may have no reserve force to spare to eject them from the system. A desire for constant increase is begotten by their use, till their well-known effects are brought about; while no increase of the ordinary nutrient materials is demanded by the body in complying with the ordinary law of waste and supply. A stimulant enables the system to use up its stored force, in other words, to borrow from itself; but this loan has to be met, and if it is not, there is a permanent deficit and physiological bankruptcy. In conclusion, the committee recommended that a less number of hours a day be devoted to practice, that as much out-door exercise as possible be taken, and that operating-rooms be large and well ventilated.

Dr. Brockway's voluntary paper showed that there is a more hopeful outlook for the dentist of the future by reason of the improved modern modes of practice. A marked change has taken place in these methods in the last decade, both in the ideas which govern them and in the means and instruments employed. In reference to the change in ideas, the prominence which has of late been given to the subject of amalgam has been observed by some with regret. From being almost proscribed it comes back to the ranks, emancipated and disenthralled by the genius of scientific and unprejudiced investigation, and takes its place as a valuable and indispensable adjunct in saving a large class of teeth. The change in this respect has been for the benefit of the practitioner in a physical point of view at least, as it saves hours of exhausting effort required in restoring with gold pulpless and more or less broken-down teeth. Another example, not so marked, is the more general use of non-cohesive foil, and the combination of gold and tin, by which the comfort and convenience of the operator are promoted (irrespective of their merits, as compared with cohesive gold), involving far less time. More enlightened and intelligent ideas upon the treatment of nerve cases and irregularity, wedging, etc., also lighten the burden of the practitioner. The employment of an assistant at the chair is also conducive to the relief of the operator, saving him a hundred little steps and movements, besides running the engine and malleting his fillings. The recent improved appliances, the mallet, the rubber dam, and the engine, were then alluded to as doing a vast and incomparable amount of good to the profession in the matter of physical well-being, besides subserving the interests of the patient. They not only relieve the severe and protracted muscular effort, as is the case with the mallet and engine, but the dam spares the mental anxiety attendant upon the operation of filling with napkins—which was far more exhausting than the physical exertion. These means are destined to work powerfully in favor of the dentist, by lessening and abbreviating his labors, leaving him more leisure to enjoy out-door exercise and recreation.

Dr. Kingsbury, of Philadelphia, said that this was a very important subject, as he had found in his own case. The dentist suffers from too close confinement. Brawn is as essential to him as brain, and this he endeavors to gain in his own experience by taking a vacation of some weeks in the summer. If there is any profession which taxes the nervo-muscular system, it is the dental. If the lawyer and the clergman require a vacation, so does the dentist, as much or more.

Prof. Barker, of Philadelphia, doubts that the profession is so exhausting; there is in his opinion no profession better calculated to prolong life and develop the faculties; and those now entering it will yet see that this is the case. The chairs in use twenty years ago were low and wide, and the position occupied by the operators then was painful and constrained. Now, what do we see? We must have an unrestrained peristaltic action of the bowels, and the man who has produced a chair that enables the operator of to-day to have this, as the chairs now in use do, deserves the gratitude of the profession. The profession of dentistry develops the man; calls for skill, ingenuity, and thought, a high action of the brain and of the physical system. Besides this, the patients with whom we have to do belong to the best classes, and mould, elevate, and increase the vital force. We may, to be sure, have a child, or some other exhaustive patient; but the next one gives strength. One reason for the prevalence of dyspepsia among us is that we ignore the simplest laws of health; we operate from morning till dinner-time, rush down to dinner, bolt our food, overtax the digestive apparatus, occupy a constrained position, and divert the blood, which the experiments of Beaumont show should normally flow to the capillaries of the stomach after eating; this blood we divert to the arms and other parts of the body. He has met dentists from all over the country, and they spend as little money in the bar-room as any other body of men; the proprietors of hotels say this also. Alcohol, as a medicine, is priceless; in consumption and some other diseases it is the main reliance.

Dr. Wetherbee, of Boston, is surprised to hear Dr. Barker advocating the doctrine that there is nourishment in alcohol. Our best American and foreign writers, who are level-headed, conclude that alcohol does not nourish. That conclusion is just, and can not be controverted. The ground has been well gone over in the papers read, and he wishes to hold up the writers' hands. Among the resources for recovery from exhaustion he would place prominently a horse, used both under the saddle and in the carriage. Horseback-riding for the dyspeptic is best, and the harder the horse the better the exercise. He himself uses both. Walking after work he finds fatiguing. Smoking and chewing are generally to be eschewed, though there may be cases where tobacco is a remedy for a terrible disease, and the only known remedy. He has been made sick by the fumes from a patient, which may do more in three hours to break down health than three days' hard work. If he had had the modern inventions thirty years ago, he would have saved several years' time; by the old style of operating, the dentist's days were shortened and made unendurable.

Dr. Kingsbury, of Philadelphia, said that he had not found horseback exercise to compare with the benefits to be derived from the forest and stream. He amuses himself on these excursions by carrying an instrument for measuring the miles he walks, and an aneroid barometer for measuring heights.

Dr. Thomas, of Detroit, said that he had found his health ruined under his former practice of walking a mile to his dinner at one o'clock. He had changed his mode of life: has his office at his residence, goes to his chair at eight o'clock, operates till two, has an hour for consultation, and dinner at three, after which he does no hard work. When he breaks over this rule he finds it detrimental. He had injured his health by too much walking and spending his leisure time in improving his residence grounds. Does not believe that the practice is the hardest in the world, though he did believe so up to two years ago. Accomplishes more in the hours that he now operates than he formerly did in one-third more time. A man who uses either tobacco or alcohol should be clean about it. Worthy men lose patients by these practices.

Prof. D. D. Smith, of Philadelphia, knows of no statistics by which we may judge of the healthfulness or otherwise of dentistry. Dr. Morgan's remarks were of that nature, and if followed up would be interesting and useful. He regards the calling as one tending to shorten life. Of the learned professions, the clergyman is the longest-lived, the physician next, and the lawyer next. True advancement in civilization and mental culture tends to longevity. That people attains the greatest average years which attains the greatest mental culture, while living upon true temperance principles. The improvement in dentistry is due not so much to applinnces as to the advance in intellectual attainments. Societies and colleges have lifted the calling to a position of great respectability since 1839. There has been a general elevation of tone throughout the profession of the country; and to it is due increased longevity. Colleges not merely teach the conservation of teeth, but educate in every department, and develop true manhood, and in proportion as they do this they lengthen the lives of dentists. All science shows that alcohol is poison, and can there be moderation in injurious things? It may be used as medicine, as arsenic is, and there it should stop.

Dr. Atkinson.—If we could lay aside partisan feeling, and endeavor to get at what constitutes food, poison, and remedy, we should be more likely to arrive at correct conclusion. We hear on the one hand that alcohol is nutrient, and on the other that it is a poison. The last speaker can not justify his dogmatic assertion. We do not know enough to assert positively what becomes of certain substances that disappear when introduced into the system. Anstie says that most of them may be collected, but still there is a portion lost. He goes with all who go against the use of alcohol, but does not want to tell a lie to bolster up the truth; he would rather be a simple *truthist*. The profession has waked up as to whether the occupation conduces to health or disease. Each man is entitled to be the best judge of how much he can endure. There is no cast-iron rule. It should be a rule, however, never to draw all our deposits out of the bank, but to keep a reserve, like buckwheat batter, which will give us a new start. The function of alcohol is to redeem the error of some man who has drawn his last deposit. Any other diffusible stimulant might be as good; red pepper or ginger; but he would prefer as a stimulant to digestion the juice of three well-ripened oranges. Our profession is the profession of professions that awakens all the elements of our being; it is the tip-top blue-blossom of humanity, that restores our patients to soundness.

TIN-FOIL FOR THE TEETH.

TIN-FOIL makes a most excellent filling on the grinding surfaces of molars when these do not antagonize; when the cavities are large and deep, the larger portion can be filled with tin, finishing with gold. Tin in buccal cavities of molars makes as permanent a filling as any material now in use. In a cavity out of sight, where there is no danger from wear, and where the shape is such as to retain the filling, tin is as perfect a protection from further decay as any material we now have. Proximal fillings of tin tipped with gold produce no unpleasant galvanic action, and are at least as perfect a protection to the cervical wall as soft gold, and much safer at that point than adhesive. Tin-foil fillings inserted as described are within the reach of many who could not afford the expense of gold, and consequently would lose their teeth; tin-foil being much cheaper than gold, and the time necessary for filling a cavity, as compared with gold, being so much in favor of tin, they are less expensive and as remunerative to the operator. —A. J. FREDERICH, in *Dental Cosmos*.

SUBLIMED SALICYLIC ACID.

SOME of the German chemical manufacturers have been trying to produce a sublimed salicylic acid, in the idea that they would thereby be able to present to the medical profession a perfectly pure preparation. Certain practitioners have believed that if they could obtain an absolutely pure article, they would avoid the caustic effects on the mucous membranes of the stomach, which sometimes occur during the treatment of chronic rheumatism, by the internal administration of salicylic acid. According to them the caustic effects were due exclusively to the traces of phenic acid, which salicylic acid is liable to contain. The results of chemical experiments are not favorable to the sublimed acid. A substance of a very beautiful appearance is produced, but it is found that the sublimed acid is very much more readily decomposed into phenic and carbonic acids, than is the usual crystallized preparation. It is, in fact, impossible to keep it in a pure state, after it has once been exposed to the air. It is evident, therefore, that care must be taken to avoid the sublimed acid, as it is so liable to decompose spontaneously, producing an actually poisonous substance. It is said, however, that some Berlin chemists have succeeded in producing an absolutely pure salicylic acid, not liable to this danger, by means of dialysis.

THE MORTUARY RECORD OF THE MUTUAL LIFE INSURANCE COMPANY OF NEW YORK.

The combined mortuary reports of the Medical and Actuarial Bureaus of the Mutual Life Insurance Company of New York have been submitted to us through the kindness of the Medical Director of the above-named company.

The experience which it sets forth is derived from a careful study of all the records of the company, from its inception to the beginning of 1874, more than thirty years.

During that time the company has been exposed to loss on 101,967 lives of different individuals, who have lived as members of the company, a duration of time aggregating 578,112½ years.

Out of this vast army of insured, 5385 deaths have occurred—something over five per cent—a most reasonable mortality certainly. We are somewhat surprised, however, to see the large percentage of deaths that has occurred among those who were only on their first year of insurance—over ten per cent of the losses thus happening. This, it seems to us, is a very large percentage; and reasoning from it, we must conclude that the average low mortality of the company is due, *not only* to the care exercised in the selection of risks, but also to a combination of many favoring circumstances. Among the causes which are charged with these early deaths, "cancer and alcoholism" show a larger percentage in the first year than in several subsequent years. We can understand how this might be the case with the latter of the two causes—alcoholism—as many a *magnificent wreck* from drink can, by a little *fixing up*, be made to still present an *appearance* of even *robustness*; but we can not see how it could be so with cancer: nevertheless, there it stands as a *fact*, and as such the report honestly states it. In the case of consumption, the value of medical selection is apparent, as the percentage of deaths from this cause during the first year is much smaller than in the subsequent years, when the advantages of selection pass naturally and rapidly away.

The value of good medical selection is also very well illustrated in "kidney diseases," including Bright's disease, where the percentage of deaths during the earlier years is very small indeed, being only 1.87 per cent for the first years whereas, further on, it rises to 6.57 per cent. Of suicides, on the other hand, out of the 59 instances reported, 13 occurred during the first year of insurance—over 22 per cent—showing that to the average medical observer this "coming event," at least, "casts but little shadow before."

Of the 38 deaths from small-pox, half occurred during the recent epidemic, teaching very clearly, we think, the necessity of a better appreciation of the preventive effects of revaccination among the people at large.

In speaking of phthisis, the medical director calls attention to the fact, that the disease is *not* one which is *confined* to the *younger periods* of life; though it is generally so considered, not only by the laity, but by physicians. The experience of that company shows that, while 525 deaths occurred from phthisis in individuals *under* 40 years of age, there were also about 400 deaths from the same cause in those who had passed 40 years. This is a point for life-insurance underwriters to consider carefully.

Old age comes in for but a small showing, only 13 deaths from this cause being cited. Every decade hereafter will no doubt rapidly swell the numbers of this class.

As to the influences of nationality on the different causes of death, we have some interesting facts—for instance, *strong drink* showed itself *strongest* among the English and Irish, and *weakest* among the phlegmatic and lager-loving Teutons.

Scotchmen seem most easily to fall victims to apoplexy and diseases of the nervous system, while the Irish fight most shy of them.

Scotchmen are also most liable to diseases of the kidneys (has oatmeal any thing to do with it, we wonder?); but, however that may be, the Scotch and Irish *know better than to commit suicide*, for *not one* case comes from among them.

The Irish contribute the largest number to consumption, and their neighbors, the English, the least; while diseases of the circulatory system and accidents are equally distributed to all nationalities. As between foreign and native born subjects, the foreign show an excess of ten per cent over natives in deaths from cancerous disease.—*Medical Record.*

OBSERVATIONS OF THE PLANET SATURN.

By L. Trouvelot.*

The observations on which this communication is based were made with the fifteen-inch refractor of the Harvard College Observatory, with the twenty-six-inch refractor of the Washington Observatory, and with the six-and-one-quarter-inch refractor of my own Physical Observatory at Cambridge. The powers used ranged, according to the amount of light and the steadiness of the atmosphere, from 140 to 700. On good nights, however, higher powers have been tried, but never with advantage, as the light lost by the use of high powers is generally of more importance for good vision than a superior enlargement with a reduced amount of light.

The following diagram, representing the outlines of Saturn and its rings, will facilitate my explanations, and give clearness to the subject:—

When looking at the rings, attention is at once attracted to a conspicuous dark line, apparently concentric with the outer margin of the rings, and boldly surrounding the planet, and adorning it by its sharp contrast. This dark line is known as "the principal division of the rings," and is shown at *a*, Fig. 1. Owing to the effect of perspective, it always appears widest at the two extremities of its major axis, on that portion called "the ansæ," as there only it is seen without foreshortening. I have carefully compared the intensity of this dark line with the sky outside of the rings, and inside of the ansæ; and I have always found it to be slightly lighter. All my observations also agree in showing this line as appearing a little narrower on the side further from the observer, at *c*, Fig. 1, than it appears on the opposite side, at *d*. This phenomenon could readily be explained by supposing that the outside margin of the ring C is on a plane higher than the ring B, and may, consequently, conceal a narrow portion of the dark line. The assumption of such a hypothesis seems to be fully supported by the observations, as will be shown hereafter. It is furthermore to be remarked, that the outside margin of the ring C has always appeared to me to be more sharply defined on that part of the ellipse farther from the observer than on the side nearest. The case is the same for the outer border of the ring A, which appears sharper on its northern than on its southern side. In both cases, the northern portion of the ellipse is limited by the matter composing the surface of the rings on their flat and illuminated side; while for the southern portion it is seen a little edgeways, and this may account for the vagueness of its outlines on this side.

Soon after the beginning of my observations, in October, 1872, my attention was called to a singular appearance not heretofore noticed, as far as I am aware. Two small, dark, angular forms, *r*, Fig. 1, were seen near the summit of the principal division of the rings on the following side, and apparently projected upon the ring B. After an interval of three hours, no sensible change could be detected in the position of these forms; and on the following day they were seen occupying about the same position. This phenomenon could easily be explained by supposing there were some sort of protuberances on the external edge of the ring C, casting their shadow under the oblique rays of the sun, which occupied then a proper position to answer to this hypothesis. But some days later, another of these singular forms was observed 180° from the first, on the preceding side, at *s*. This at once overthrew the supposition that they were shadows cast by protuberances existing on the ring C; since in this case the shadows would have been projected opposite the sun on the

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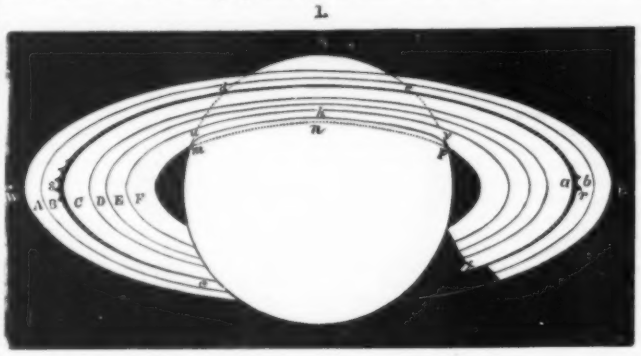

ring C, and not on the ring B. Since that time, I have rarely observed the planet without seeing some of these singular appearances, either on one side or the other, but generally on both sides. The number of these dark forms is variable. One, two, three, four, and even five, have been seen at the same moment, and on the same side. Though these forms are variable, and appear and disappear, I have never been able to detect in one night any change of position which could be ascribed to the rotation of the rings.

The most plausible explanation of the phenomenon which I can conceive is, that the inner margin of the ring B, which forms the outer limit of the principal division, is irregular, jagged, and deeply indented, as shown at *a*, Fig. 2, which represents Saturn as it would appear to an observer placed above one of its poles.

Though no noticeable changes in the position of the dark angular forms could be observed in the course of two or three hours, it does not follow that the system of rings does not rotate upon an axis, as theory indicates; since the supposed indentations seen on the ansæ would be placed in the most unfavorable positions for showing their motion, if they have any, because it would be accomplished almost in a line with the visual ray, either approaching or receding from the observer.

Next to this division, but much less conspicuous, and to be seen only on very good nights, is a narrow, grayish, and somewhat diffused line, called "the pencil line," shown at *b*, Fig. 1. I have never been able to trace this line all around the planet, as it diminishes very rapidly with the foreshortening, and is soon lost. Probably I have never traced it more than 30° or 40° on each side of the major axis of the rings. The pencil line has never appeared to me black and well defined, but rather grayish and diffused. Sometimes I have had the impression that it was irregular in width and in depth of tint.

These two lines are the only ones I have observed, which could, with a certain amount of probability, be said to be a separation of the rings; though they might just as well be depressions, or dark belts, especially the outer one. But the fact that they have been observed on both surfaces north and south, apparently corresponding in position, is in favor of their being real separations of the rings. Though I have re-

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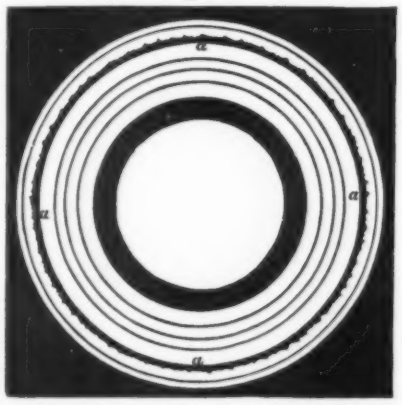

peatedly endeavored to see the planet through the principal division between *d* and *e*, Fig. 1, I have never seen the faintest traces of it; and I am not aware that others have been more successful.

If the principal division of the rings is, in fact, what it is said to be,—namely: a space free from matter, and entirely disconnecting the rings B and C,—I do not see why the planet has never been seen through it. If the planet could be seen through that space, the dark line forming the principal division would be invisible from *d* to *e*, as the bright light of the planet would shine through in its place, and be undistinguishable from that of the rings. It may be objected that the invisibility of the planet through the principal division is due to the thickness of the ring C; but in this case, why should the black sky be seen if the planet is invisible?

Besides the two dark gaps or divisions of which I have just spoken, the rings are subdivided by concentric zones or belts, which reflect light of different hues and intensity. Though only three of these belts are conspicuous, I have found by careful examination that there are six which I can always recognize whenever the illumination is good and the image steady. These zones are represented on the diagram, Fig. 1, at A, B, C, D, E, F. On several occasions I have had a pretty distinct impression of seeing the whole surface, from C to E inclusive, grooved, as it were, by numerous narrow concentric belts. These impressions may have been illusory, as they were almost instantaneous; but I have since learned by experience that, after all, rapid impressions are not so much to be discarded, as, quite often, even more fugitive impressions have proved in the end to be real.

In order of brightness, the zones or belts composing the system of rings run as follows: C, D, B, E, A, F; C being by far the brightest, and F by far the darkest. The zones A and B have a bluish cast or light slate color; C is of a bright luminous white; D is slightly grayish; E is a little darker; while F, which is very dark, is tinged with bluish purple.

A is separated from B by the pencil line; B from C by the principal division; while the others do not show any separation whatever, and are only limited by the contrast of their different colors and shades, and seem to be in immediate contact. However, the different zones do not terminate abruptly where they come in contact, but seem somewhat blended into each other. This is especially the case between E and F. Though at that point the contrast between the two internal rings is very great, yet it is impossible to see any line of division, so much do they mingle at their point of contact.

On good nights, I have often observed on that part of the rings A, B and C, seen on the ansæ, an unmistakable mottled or cloudy appearance such as is represented on Plate I. This appearance was always more characteristic and better seen on the ring C, especially near its outer margin, close to the principal division. It would seem, as has been already remarked, that the ring C is on a higher level than that of the rest of the rings, and that the cloudy appearances observed there form by their accumulation some kind of protuberances of different heights and breadths. The bright spots resembling satellites, so often observed by Bond in 1848, when the plane of the rings was parallel with that of the ecliptic, were probably caused by the crests of some protuberances similar to those now seen on the ansæ. The form of the shadow thrown by the planet on the rings on November 30, 1874, as shown at *x*, Fig. 1, seems also to agree with this hypothesis. The curious and deep indentation of the shadow at *x*, in that part where it is projected on the outer border of the ring C, is perfectly explained on the supposition that this part of the ring is on a higher level. The same shadow, as it appeared projected on the rings B and A, also clearly indicates that the plane of these zones is on a lower level.

EXPERIMENTS DEMONSTRATING THE DIFFERENT LEVELS OF THE RINGS.

In order to find the shape of the surface of the rings from the observation of the form of the shadow thrown by the planet, I have experimented on a miniature representation of Saturn, illuminated by a lamp occupying the position of the sun, while my eye occupied the position of the earth. By successive trials in altering the shape of the miniature rings, I have soon found what must be the form of the rings in order to give to the shadow the same appearance which had been observed on the planet; and the result agrees with the explanation already given.

From the form of the shadow as it has appeared at different times during the last four years, and from the experiment just mentioned, it seems pretty clear to me, that, from the inner margin of the dusky ring F, the thickness gradually increases until it reaches the extreme border of the ring C, where it gently decreases, as indicated by the rounding of the shadow at this point, after which it sinks perpendicularly down until it comes even with the general level of the rings B and A. The slightly curved appearance of the shadow of the planet during the present year, with its concavity turned towards its globe, also supports this hypothesis.

Though in general the level of the ring C is always higher than that of the rest of the system, it does not seem, however, to be uniform and permanent, but varies either by the rotation of the rings upon an axis, or by some local changes in the cloud-forms themselves; as in several instances I have observed quite rapid and striking changes taking place during the course of one evening in the indentation of the shadow shown at *x*, Fig. 1. Sometimes the indentation appeared to increase, indicating a higher level; and sometimes to decrease, indicating a lower level.

That the thickness of the rings is increasing from the interior margin of the dusky ring to the outer border of the bright ring C, seems to be corroborated by the phenomena which I have observed on the dusky ring, and of which I shall speak presently.

On all favorable occasions, I have made careful searches on the dusky ring, for the divisions suspected by Bond; but I have never had the faintest glimpses of them. The dusky ring appears to me to be continuous, though it is certainly not of the same thickness throughout. Whatever may be the material of which this ring is composed, it is quite rarefied; and it becomes more and more so as it approaches its inner margin. There, it seems to be composed of discrete particles, each of which reflects the light separately; and by applying high powers to telescopes of large aperture, I have had the impression that the supposed particles were more widely separated by the increase of magnifying power. I do not pretend to have seen distinct and isolated particles in the dusky ring; but by instants my impressions have been so decided, that it seems as if only a little more favorable conditions were required to enable me to see separate corpuscles of matter. The appearance was somewhat like fine particles of dust floating in a ray of light, traversing a dark chamber.

The inner border of the dusky ring, notwithstanding its dark appearance, is sharply defined on the dark sky within the ansæ; but it loses this sharpness of outline, in that part which is seen projected upon the disk of the planet. There it appears very diffused and ill-defined.

The inner border of the dusky ring, as seen within the ansæ, forms a part of a perfect ellipse, concentric with the other rings; but these graceful curves are remarkably and quite abruptly distorted where they enter upon the disk of the planet at *m* and *p*, Fig. 1. At these points, they are seen turning up rapidly, describing a short curve; after which they continue parallel with the curves of the other rings until they meet at *h*. If the ellipse described within the ansæ should cross the planet without any deflection, it would be seen along the dotted line, Fig. 1, and pass through *n*; while, on the contrary, it is seen above at *h*.

* Abstract of a paper read before the Amer. Acad. of Arts and Sciences, 1876.

COMPOSITION OF THE DUSKY RINGS.

I was surprised, at first, by this singular phenomenon; but I at last satisfied myself with the following explanation: If we conceive the dusky ring to be made up either of vapors or of numerous small independent solid bodies, and, moreover, if we conceive the thickness of this ring as increasing from its interior margin to its outer limit, we shall have an easy explanation of the observed phenomena. When the matter composing this ring, whether solid or gaseous, is seen projected upon the disk of the planet, brilliantly illuminated, it will be lost, and will individually disappear, absorbed by the irradiation of the bright light surrounding it, and it will remain visible only at that part where it forms a stratum thick enough to overpower the effect of irradiation.

The fact that the distortion of the inner margin of the dusky ring is not abrupt at *m* and *p*, where it enters upon the disk, but is gradual, seems to prove that the planet is less luminous on its border than elsewhere, providing the above explanation holds good; and this may be owing to the absorption caused by an atmosphere surrounding the planet.

RECENT CHANGES IN THE DUSKY RINGS,

Bond has represented the limb of the globe of Saturn as seen through the whole width of the dusky ring. In this he agrees with all previous observers. All the drawings of Saturn represent the limb of this planet as plainly and equally visible throughout the dusky ring, becoming invisible only where it enters under the internal margin of the ring E. In Bond's memoir, it is positively stated that Mr. Tuttle saw the limb of the planet through the whole width of the dusky ring. If these observations are correct,—as without doubt they are,—the solid particles, vapors or gases, composing this ring, must have undergone some changes of position since Bond's time; as by using the same instrument, and even one of almost double the aperture, I have not been able to confirm these observations.

During the last four years, I have never been able to see the limb of the planet Saturn under the dusky ring, beyond the middle of its width. As it enters under it at *m* and *p*, it remains quite distinct for a short distance; but, as it advances farther in, it diminishes gradually; and it entirely vanishes at about the middle, at *u* and *v*; as if the matter composing the dusky ring was more dense or thicker towards its outer border. This observation has been so carefully made, and so many times repeated, the phenomenon has been so distinctly seen, that there is not the least doubt in my mind as to its reality. Therefore it seems pretty certain that changes have lately taken place in the distribution of the matter composing the dusky ring.

As already shown, the substance composing the dusky ring does not seem to be uniformly distributed; but seems moreover to be agglomerated here and there into denser masses, which I have often recognized upon that part of the dusky ring crossing the planet between *u* and *v*. These supposed agglomerations appeared as dark masses, intercepting the light of the planet. This phenomenon could not be attributed to dark markings on the planet, seen through the dusky ring; since there are no markings so dark and so small on Saturn. Neither could they be produced by the dark bands sometimes surrounding the globe of Saturn, as some traces would have been detected on the edge of the dusky ring, since these bands are usually wider than the transparent part of the dusky ring.

THE CLOUDS AND COLOR OF SATURN.

Of the planet itself I have little to say. It has certainly a mottled or cloudy appearance, like Jupiter. The clouds of Saturn are more finely divided, like certain forms of the cirri clouds of our own atmosphere. The cloudy appearance of Saturn, of course, is not so easily seen as that of Jupiter. It always requires a good steady night to see it.

I have never seen the planet striped with a large number of parallel bands, such as some observers have described. Three or four form the extreme limit. Nor have I seen the bands so conspicuously marked, so regular, so distinct in outline, and so dark; the equatorial band being always by far the most conspicuous, while the others were barely perceptible. The equatorial belt has always appeared to me to be slightly tinged with a delicate carmine red, very much like the equatorial belt of Jupiter; only the pink color of the former is much fainter. In no instance could I compare the color of this band to "brick red," as it is commonly described.

Like the equatorial belt of Jupiter, that of Saturn is variable in width, and changes its form as well as its position. It is usually composed of two grayish, irregular bands, forming its limits north and south, between which are seen flocculent pinkish cloud-forms.

The general color of the planet differs from that of the rings, in being of a slight warm brown in which there is a yellowish tinge. The contrast of color with the rings is better seen by the use of very high powers.

To conclude: my observations show,—

I. That the inner margin of the ring B, limiting the outer border of the principal division, has shown on the ansæ some singular dark angular forms; which may be attributed to an irregular and jagged conformation of the inner border of the ring B, either permanent or temporary.

II. That the surface of the rings A, B, and C has shown a mottled or cloudy appearance on the ansæ during the last four years.

III. That the thickness of the system of rings is increasing from the inner margin of the dusky ring to the outer border of the ring C, as proved by the form of the shadow of the planet thrown upon the rings.

IV. That the cloud-forms seen near the outer border of the ring C attain different heights, and change their relative position, either by the rotation of the rings upon an axis, or by some local cause; as indicated by the rapid changes in the indentation of the shadow of the planet.

V. That the inner portion of the dusky ring disappears in the light of the planet at that part which is projected upon its disk.

VI. That the planet is less luminous near its limb than in the more central parts, the light diminishing gradually in approaching the border.

VII. That the dusky ring is not transparent throughout, contrary to all the observations made hitherto, and that it grows more dense as it recedes from the planet; so that, at about the middle of its width, the limb of the planet ceases entirely to be seen through it.

VIII. And, finally, that the matter composing the dusky ring is agglomerated here and there into small masses, which almost totally prevent the light of the planet from reaching the eye of the observer.—*American Journal of Science and Arts.*

THURSTON'S AUTOGRAPHIC TORSION MACHINE, AND EXPERIMENTS.

As the knowledge of the resistance of materials of construction is of importance to the machinist, so the quality and property of the raw material is of equal importance to those engaged in the mining industries, for the better the quality of the ore the higher will be its market value, and the greater the demand for it; some interest will, therefore, attach to a machine having for its object the testing of different materials to continuous strains of torsion, through all the successive strains until final rupture takes place. The machine itself was designed by an American, Prof. Thurston, and is intended to analyze and register automatically the action of physical and molecular forces in resisting stress, and the relation between the moment and the angle of torsion throughout the entire process of any experimental inquiry. Suppose that prepared test specimens have been made 3½ in. long, with the middle turned down to 1 inch long and ½ in. diameter, and with fillet turned out to 1/16 in. radius at each end. This specimen having been centred and blocked carefully in the machine, with the paper adjusted under the marking pencil, the sample is next twisted off very slowly and steadily, taking duplicate registers of strain before ultimate fracture is allowed to take place, so as to obtain the elastic line. A diagram figure is thus obtained. The autographic curves described by the machine, and belonging to the different materials, show the homogeneousness or otherwise of a material tested. A perfectly straight line between the elastic limit, and perfectly parallel with the elastic line, shows the material to be homogeneous as to strain—that is, to be free from internal strains such as are produced by irregular rapid cooling, or by working too cold. Any variation from this line indicates the existence and measures the amount of strain. A considerable curved line exhibits the existence of such strain. The form of the curve immediately passing the elastic limit may be next examined. If the curve rising from the latter is regular, and approximately parabolic and concave in form towards the base line, then homogeneousness in structure is displayed, and the absence of imperfections guaranteed, such as are produced in wrought-iron by cinder, or produced in cast metals worked from ingots by porosity of the ingot. As an additional test, submit several specimens of the same kind of material to the machine, and compare diagrams. Homogeneousness in general character and homogeneousness in composition may be detected by a precise similarity of these diagrams; consequently the greater the dissimilarity between the curve the less homogeneous will be the corresponding materials. But the deficiency of homogeneity may be likewise detected if on passing the elastic limit the curve turns sharply, and then runs nearly or quite parallel, or actually becomes convex towards the base line, resuming after a time an upward movement by taking its proper parabolic path. Proceeding to the various practical problems which may be answered by means of the strain diagrams produced by the autographic torsion machine, the scale of the diagram of the standard machine is 300 ft. lbs. in torsion, equivalent to 30,000 lbs. per square inch tensile resistance. Supposing, then, it were required to determine the elastic resistance of any specimens by means of its autograph curve, the height of the curve at its elastic limit would have to be measured and interpreted by the scale of torsion or tension which is given for each machine, and for each standard size of test piece. The experimenter might also determine the resistance offered to any given amount of extension, or that producing a given set, by measuring the curve, or rather its height, at the point whose distance from the origin measures the assumed degree of set. Again, by measuring in a similar manner the maximum height of the curve would give the ultimate resistance of the material. The total resilience or shock-resisting power of the material is represented by the total area of the diagram, or an approximate value for ductile materials may be obtained by taking two thirds the product of the maximum tenacity by the maximum extension. One half the same product gives very accurately the corresponding values for hard and brittle materials, whereas for intermediate qualities the true value is nearer two thirds of this product. As practical examples, Swedish wrought-iron, white cast-iron, and hardened steel illustrate the first and second classes, and ordinary tool steels are examples of the third class. To determine the effect of a load given in pounds per square inch, such a point on the curve must be found that its height above the base line is equal to the load per square inch, then its distance from the origin measures the extension of the material as produced by that stress.

Epitomizing the general results obtained by the machine as bearing on general constructive principles, it is claimed to enable the constructor to select the proper kind of iron for any specified purpose. Where mere strength is required tool steels will recommend themselves as the best materials, but where ductility is desired something resembling Swedish iron will be the proper material. Since in situations subject to the resistance of shocks or blows mere strength of material is not sufficient, the metal combining ductility with the necessary strength should be chosen in such sites. Tool steel is too brittle a material to be used in such situations, and even moderately hard steels have been looked upon as being less valuable for such purposes than moderately good iron; in general the metal giving the highest product by its main resistance into the distance through which it stretches before breaking, is the safest against rupture by blows, and it will be advisable in cases where two different metals show equal products in this respect to choose that metal which shows itself to be the strongest. The diagrams taken by Thurston's machine show, with regard to the value of a material to resist shocks, that excepting the very purest and most expensive wrought-irons, the low steels excel all other materials in this respect, while they are stronger than iron; hence the theoretical reason for the amazingly rapid introduction of steel rails for railway and other machinery purposes.

Quite apart from these considerations, Prof. Thurston appears to lay claim to some important revelations on the resistance of materials of construction, as the following experiment described by him will show: A test piece of wrought-iron was left in the machine, exposed to a strain which had passed the limit of elasticity, and with a distortion of 45°. It was intended to determine whether, as had been suspected by some writers and by many contemporaneous engineers, "viscosity" was a property of solids, whether a flow of solids could occur under long-continued strain just as equilibrating, when first applied, the resisting power of the material, or whether the "polarity" of Prof. Henry was an absolutely unrelaxing force. The metal was left under strain twenty-four hours, and had not then yielded in the slightest degree. This result, and the result of other similar experiments since made, confirming it, indicate that metal strained far beyond the limit of elasticity, as above described, does not lose its power of resisting unintermitted static stress. The important bearing of this fact upon the availability of iron, and of steel, which also behaves similarly for use in constructions exposed to severe strains, is readily seen. After noting the result obtained, as stated, it was attempted to still further distort the test piece, when the unexpected discovery was made that its resisting power was greater than when left the previous day, an increase of resistance being recorded amounting to about 25 per cent of the maximum registered the preceding day, and approximating closely to the ultimate resistance of the material. Repeated experiments, continued up to date of writing, confirmed the following previously undemonstrated principle: That iron and steel if strained beyond the limit of elasticity, and left under the action of the distorting force, which has been found just capable of equilibrating their power of resistance, gain resisting power to a degree which has a limit in amount, approximating closely, if not coinciding with, the ultimate resistance of the material, and which had a limit as to the time in experiments hitherto made of three or four days. Releasing the piece entirely, and again submitting it to the same force immediately, does not produce this strengthening action. There is some evidence, confirmed by theoretical dynamic principles, that the increase of strength noted is not accompanied by a change of resilience, but that the gain of resisting power is at the expense of a proportional amount of ductility. The interest and importance attaching to the discovery of the principles above enunciated to the engineering profession, as well as to science, are worth consideration.—*Mining Journal.*

JET MINING AND WORKING.

FOUND generally in the upper lias bed, once along the coast from Whitby to Staithes, and now chiefly in the Cleveland hills, jet has been long worked in Cleveland—so long, but until latterly so quietly, that history records not its early phases. Whitby has long been associated with, first, jet mining, and latterly with jet working; and although newer and more expansive trades have been introduced into that ancient town, jet working is still its staple trade, but mining for the material seems to be removing to a greater distance from the town. The cliffs to the north of Whitby have furnished some of the most valuable finds, and a seam met with some two or three years ago near Codhill was estimated to be of the value of £1000; but of late the chain of hills from Ingleby Greenhow towards Northallerton have been the chief places worked, and at present the inner sides of the hills converging into Billsdale furnish the bulk of the jet now sent from Cleveland to the chief seat of manufacture. Along the coasting cliffs jet is sought by what is called "dressing," or literally quarrying down the seaward face of the cliff, and some valuable coastside seams have been discovered by the action of the sea, but in the hills tunnelling, much in the manner of the Cleveland iron mines, but in a less systematic mode, is the invariable way. The stratum in which jet is found lies below the alum rock; it is usually some 20 ft. in thickness, and as old workings of some 6 or 8 yards deep abound, these must be cut past. Generally a drift is run in for about 80 yards nearly level; the shale and earth being run out and tipped down the face of the hill. From the drift, cross-sections are cut about 150 ft. in length, and in these the miners pull down with pick and shovel the earth, retreating before it till each way is thus worked out. The jet is invariably horizontally found, and the miners found, partly on this, a theory that it has at some time been liquid. The mode of working the mines is peculiar to the trade; it is neither by royalty on output nor lease of pits, but it is by payment for the right to work from a certain area of foreground—usually 200 yards—to any depth, the number of men being restricted to six on an average for the length of foreground stated. Three years ago in Billsdale alone there were above 200 jet miners thus at work, with a few companies near Guisborough additional. Now, through the decline in the demand, and the importation of Spanish jet, the number is much fewer. The mode of payment of the miners varies; in one or two instances the amount realized by the sale of jet, after the payment of ground rent, is equally divided amongst the fine workers and the "jet master" who has furnished the capital; in another the co-operative system has been tried, the men receiving a certain amount of subsistence money and equal shares in half of the net receipts, the remaining half being the master's remuneration; but the bulk of the miners receive a weekly wage, and prefer the system. Hence, the risk is generally the jet master's, and though the price of jet has been high—in some cases as much as 16s. per lb. has been paid for choice specimens—yet when it is remembered that the price is a fluctuating one, that the quantities found are usually small, and that they are lessened by the "doggers" found in the seam and by the dazed jet—that which will bear no polish—it will be found to be a hazardous speculation. For the miner, when demand is fair, as tools—save the spade—are found him, as the work is of some eight hours daily, and though laborious, is largely free from accident, the wages paid contrast most favorably with that for agricultural labor, of which it is the substitute in most cases. Whitby is the almost invariable place of jet "manufacture." The first process is—after the removal of the "scar," dirt, etc.—the sawing of the block into sizes suited to the objects for which it is to be used, and then the rubbing on small grindstones, driven rapidly by a treadle, and it then passes into the carving rooms. Here, with small leather-bound chisels, the pattern is cut, foot lathes cutting the holes in flower pieces, etc., and of late the artistic nature of these cuttings and carvings is greatly improved, whilst a further excellence appears to be probable from the associated efforts of many interested in the jet trade. And as a result of this there is a greater fidelity to nature visible in the fruit and flower pieces, an increasing nicety in the shaping of the necklaces and coronets, and a greater approach to artistic outline in the shaping of the heads of brooches. After this cutting the carved goods are polished, which is effected by their being held against rapidly revolving wheels, which are covered with chamois leather, the hollow parts being rubbed with strips of list, the polish being given by lampblack. The value of the jet trade to Whitby has been variously stated—as low as £20,000, and as high as five times that amount has been stated, and probably now the produce of it will be nearest the latter amount, whilst the number of persons employed in Whitby in the trade is said to be above 1200.—*Mining Journal.*

TRADE AND MANUFACTURE IN THE UNITED STATES.

NOTWITHSTANDING the exaggeration which is sometimes used in referring to the growth of foreign competition with British manufactures, the evidence of its increasing vigor and keenness is too substantial to be neglected. And there is no nation whose rivalry in this respect we have more reason to treat seriously than the United States. A letter addressed

to the *Times*, by Mr. Douglas Galton, calls attention once more to the formidable manufacturing power which is growing up on the other side of the Atlantic. Mr. Galton was one of the judges in the group for railway appliances at the Philadelphia Exhibition, and besides fulfilling his duties as such he appears to have devoted considerable time to the study of the recent progress of American industry. Having visited the United States in 1856, he was able to make a fair comparison of the rate of advance within the past twenty years. He says that the activity awakened by the war, aided by the protective system, has developed and nursed every variety of manufacture, from iron rails to Parisian fancy articles. So much for its expansion in respect of variety. As to its aggregate extent, he points out that whilst from 1870 to 1874 the annual production of coal in the United States increased from 32,000,000 to 50,000,000 tons, that of Great Britain rose only from 113,000,000 to 125,000,000 tons. Of the 50,000,000 of tons raised in 1874 only 500,000 tons were exported, of which about 400,000 tons went to the Dominion of Canada. The coal fields of the United States cover an area of 196,000 miles; the coal is in most cases easily accessible; iron ore is abundant, both near the coal fields and elsewhere. Mr. Galton observes that notwithstanding the stagnation in trade in the United States he noticed several new works in course of erection. The iron-works do not appear to be employed so much in the production of rails for new lines, but of steel rails, which are being substituted for iron ones. He says it is not probable that England will much longer be able to supply rails to the United States, and the returns of the Board of Trade certainly seem to confirm this view. Mr. Galton gives statistics with respect to wages which appear to show that although rather high they are lower than is commonly supposed, and he says that the working day is at least ten hours. He point out that unskilled labor is much more extensively used to guide machinery than in England. Mr. Galton advances no reasons for the increasing superiority of American industry beyond the allusions to the length of the hours of work, the use of unskilled labor, and the fact that the manufacturers work with great energy. But he strongly urges English employers to visit the Philadelphia Exhibition, and themselves investigate the causes of a growing competition which they can not afford to despise.—*Mining Journal.*

CORALS FROM PERU, NEARLY THREE THOUSAND FEET ABOVE THE SEA-LEVEL.

Professor A. Agassiz, in his recent SouthA-merican tour, found a coral limestone at Tilibiche, 2900 to 3000 feet in elevation, about 20 miles in a straight line from the Pacific. The ravine where it occurs is about 450 feet below the general level of the nitrate basin of Peru. Two species of corals, modern in aspect are described by L. F. Pourtalès, both new species, *Isophyllia duplicata*, and *Convexastræa? Peruviana*, and besides these a Millepore was observed near *M. alcicornis*. Professor Agassiz concludes that the Pacific, within comparatively recent times, extended through gaps in the coast range and made an internal sea, which stood at a height of not less than 2900 feet, and probably much above this, as the sea must have played an important part in the deposition of the salt and the nitrates of the nitrate beds; and consequently, that there has been an elevation since the formation of the coral reefs of not less than 2900 feet. The presence of other extensive saline basins at a height of 7000 feet seem to make the submergence still greater. The existence of eight species of *Allorchestes* (amphipod crustaceans), a salt-water genus, in Lake Titicaca, is stated to suggest the presence of the sea, at no very distant period, at a height of 12,500 feet.—*Bull. Comp. Zool.*

The facts have a special interest from the fact that there are now no coral reefs on the South-American coast south of Cape Blanco, near the equator, owing to the cold oceanic currents of the coast. The coast range would have been a protection against those currents in the era of the Tilibiche coral reefs.—*Amer. Jour. Sci. and Arts.*

THE LOWE GAS PROCESS AT THE PHILADELPHIA GAS WORKS.

This method, which has received occasional notices in these columns, has the merit of achieving greater successes with each new appearance. The excellent results accomplished by it during some nine months' trial in the city of Utica, an account of which was published in reports by Prof. H. Wurtz and H. H. Fish, the manager of the Utica Gas-light Company, were attracting very general attention when its operations were brought to a standstill by a fire that destroyed the wooden building in which the works were located. Nothing daunted by this disappointment, the owners sought for an opportunity to demonstrate their system on a still larger and more conclusive scale, and were so fortunate as to make arrangements with the Philadelphia Gas Trust for a trial of it at their Manayunk Station. The new process has recently "blown in" there, and it is pleasant to state that the results are most gratifying and show already a decided advance in some particulars over those obtained at Utica. The generators, of which there are three, are 40 inches in diameter, instead of 30 inches as before. To each of these there are two—instead of one as formerly—of the stacks, called superheaters, filled with loose fire-brick. The products of combustion are divided between these, and when heated up sufficiently one serves, as formerly, for the thorough fixing of the gases; the other, to superheat the steam before its entrance to the base of the coal chamber.

This is a new feature, suggested by the excess of heat evolved by the apparatus at Utica, which is thus, in a most simple manner, utilized with great advantage. The temperature attained by a jet of steam passing down through a column of fire-bricks 15 feet high and 30 inches in diameter, standing at a white heat, is enormous and has produced surprising results. The increased facility of generation was immediately noticed, the delivery of gas, instead of 3,000 feet, which was considered a good result at Utica, at once attained 8,000 feet to a run of thirty minutes in one generator. Two days later, over 10,000 feet were run, and on the 10th August 13,400 feet. What the limit of capacity may be, will only be developed by increasing familiarity with the new works. It seems also that the high temperatures tend to reduce the proportion of carbonic acid in the gas, thus simplifying its purification. The Lowe process is apparently entitled to take its place among the useful arts of civilization, and we hope it may effect the permanent improvement and cheapening of light, and let us also hope it may be successfully applied to the economical production of heating gas. It certainly furnishes a striking illustration of the persistency of inventive men, for the attempt to make "water gas" practically and economically, dates back to an early year in the century, and the present success has been won only after many failures and disappointments. We look upon the practical solution of the water-gas question as a most important matter for metallurgical science, and we hope this successful application of this interesting process will be thoroughly investigated by competent experts. We would suggest to the owners, as a sure way of obtaining the general recognition of what is of value in this process, an examination by, say, three experts, two of whom they might request the Institute of Mining Engineers and the Gas-light Association to appoint.—*Engineering and Mining Journal.*

THE GRAMME ELECTRIC MACHINE.

To the Editor of the Scientific American:

In making a working drawing of the Gramme machine, the question arose as to the manner in which the coils in the revolving bobbin were wound, and as a knowledge of it was of some importance, I made a series of measurements of the resistance of different portions of the coil, in order to see if they would give any clue as to the manner of winding. The method which the measurements indicated was unique, at least to me; and as I have never seen any but contradictory descriptions of the machine, I give it below, thinking it may be of interest to some of your readers.

As drawings and description of the machine are given in *Science Record* for 1875, and in the Supplement for April 22, 1876, I will assume your readers familiar with the general construction and theory of the machine.

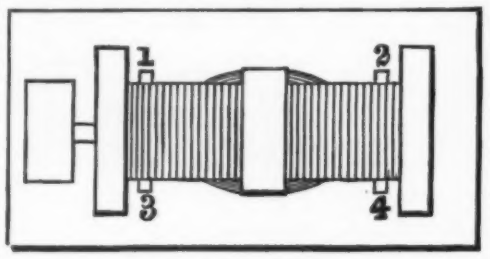

Fig. 1.—TOP VIEW.

In Fig. 1, the points marked 1, 2, 3, and 4 are the brushes. Wires are run from 1 and 4 to the light, and from 2 and 3 to the inducing magnets. Disconnecting the coil from the light and inducing magnets, and measuring the resistance between the brushes, I find:

From brush	1	to 2 — .5	ohm
"	"	1 to 3 — .25	"
"	"	1 to 4 — .3	"
"	"	2 to 3 — .3	"
"	"	2 to 4 — .25	"
"	"	3 to 4 — .5	"

We notice in the above table of resistances that there is an equal resistance between 1 and 2, and 3 and 4; also an equal resistance between 1 and 3, and 2 and 4. This shows the coil is symmetrically wound; and the fact of there being twice as much resistance between 1 and 2, and 3 and 4, as between the others, points to such a winding as would cause the current in passing from 1 to 2, etc., to pass through a greater amount of wire. The only other facts I was in possession of were, that the machine revolved more rapidly when the carbons were in contact than when they were separated, and that a battery applied to 2 and 3 would cause the bobbin to revolve while it produced no effect in other positions.

In order to determine the method of winding, I put the conceivable cases into the form of logical propositions. Either the coil is wound with (1) one conducting wire (however arranged), or (2) it is wound with two wires. (And since the case of two wires afterwards joined would be, electrically considered, one wire, the two wires must in this case be entirely separate.)

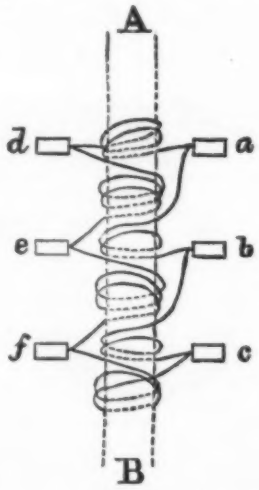

Fig. 2.

If (2) is the case, either the wires are connected to alternate strips on the commutator, or they are connected one to one commutator, and one to the other. If they were connected to alternate contacts, between some two of these contacts, I could not get circuit; but I do, on all. If it was connected one wire to one side and one to the other, I could not get circuit across; but I do. Therefore, it is not wound with two independent wires. The continuous wire, then, could be (1) connected alternately with each commutator; or (2) it could be connected entirely with one side; or (3) it could be wound in two sets of coils, alternating on the ring, one set connecting with each commutator, and the ends joining so as to form one metallic circuit. (See Fig. 2.)

If (1) was the case, there would be very little resistance between 1 and 2; but right there is the greatest resistance, (2) is not true from an inspection of the machine, (3) then must be true.

Fig. 2 will give an idea of the method of winding called (3) in the above argument: *a*, *b*, *c*, are metallic strips on one commutator; *d*, *e*, *f*, strips on the other. The dotted lines from A to B represent the iron ring, on which all the coils are wound.

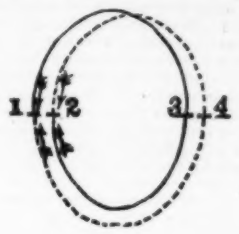

Fig. 3.

Fig. 3 will now give an idea of the complete circle of coils. The full lines represent those connecting with the right-hand commutator—the broken line those connecting with that on the left. The numbers show the position of the brushes on the circle. Here we see that the relative resistances would be such as the measurements would call for. In order to show how the circuits would flow in the connecting wires, I will represent the induced currents as batteries (Fig. 4).

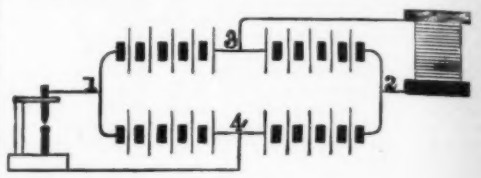

Fig. 4.

By following those currents under the different circumstances, we find that the change in speed and the rotation of the bobbin by batteries are explained perfectly.

While it is true that this conclusion may not be as certain as could be given by an actual dissection of the machine, still, as far as measurements and other considerations would indicate, it appears to be correct.

Brown Ayres.

Stevens Institute of Technology,
Hoboken, N. J., September, 1876.

CHANGE OF VOLUME OF ELECTRIC CONDUCTORS.

Herr Exner has measured the change in length of a conductor through which an electric current is passing, by a method free from the error caused by the expansion due to the heat generated by the current. Two pieces of the same wire of nearly equal lengths were hung one over the other, and so connected with a battery that the current might be passed through either. The lower wire passed through a glass which might be filled with water if desired. The elongation was measured by resting the end of the wire on a lever carrying a mirror whose deflection was read by a telescope and scale. The current being passed successively through the two wires, a different deflection was obtained in each case, but these were rendered equal by inserting an additional resistance in circuit with that wire whose elongation was greater. The tube was now filled with water so as to carry off the heat generated in the lower wire as rapidly as possible. It was found that the galvanic expansion was only 1.2 to 2.2 per cent of the heat expansion; and no connection was recognizable with the nature of the metal employed. If it be considered that these values, of course, can only be an upper limit, it will follow from the smallness of the effect obtained that there is no sufficient ground for the hypothesis of a special expansion power of the galvanic current. There can hardly be any doubt that the slight expansion which the water-enclosed wire shows is simply and alone due to the heat remaining in it.—*Nature.*

ACOUSTIC ATTRACTIONS.

M. Dvorak has examined the attractions and repulsions of small pendulums hung near sonorous bodies. A square of paper, or a piece of cork, is hung by a silken thread, and held near a wooden rod vibrating slowly. Varying the positions of the pendulum it is sometimes attracted and sometimes repelled. These motions seemed to be due to the air-currents approaching or receding from the rod, and the motions of the cork served to determine approximately the directions. These results were verified by the motions of a flame and the indications of a very sensitive water manometer. The air thrust aside by the vibrating rod escapes laterally, repelling light bodies. This is replaced by air forming counter-currents toward the rod, producing the effect of attraction. When the amplitude of the vibrations is small, the rod acts like the prongs of a tuning-fork, and attraction takes place in every direction.

In front of the opening of a tube of Kundt is placed a second open tube, giving the same sound as the first, and suspended by two threads. Making the first tube resound loudly, the second tube is strongly repelled. The same effect is obtained if the second tube gives one of the harmonics of the first. Placing two tubes facing each other opposite the tube of Kundt and perpendicular to its axis, they tend to approach each other. With a very sensitive manometer it appears that in a column of air in a state of permanent vibration, the air at the nodes has an excess of pressure. This accounts for the heaping up of water in the loops of a tube of Kundt. It is explained by admitting that the amplitude of the vibrations can not be neglected compared with their length. It follows that there ought to be a continuous motion of the air from a node to a loop. This might be proved by filling the resonant box of a tuning-fork with the fumes of chloride of ammonium and seeing if they are thrown out when the fork is set in vibration.

If a bell is filled with water and a drop of oil allowed to fall on it, the circular film becomes quadrangular when the bell is sounded. The water-currents start from the nodes and accumulate at the loops. A disk of glass is attached to the end of a rod vibrating longitudinally. If a glass drop is hung opposite the disk, it will be repelled at the centre and attracted around the periphery. There are then, as with air, currents outward at the centre, and counter-currents inward along the edges.—*Journ. de Phys.*